The Blast Furnace and Steel Plant

"War Meeting" of Iron and Steel Institute

Pronouncements of Chairman Gary and General Goethals on Steel Contribution to the War Arouse Widespread Interest—Interesting Program of Technical Papers Heard at the New York Meeting.

The twelfth general meeting of the American Iron and Steel Institute, held at the Waldorf-Astoria, New York, on May 25, probably will go down in the history of the Institute as the "War Meeting," because of the immensely important announcements by the President of the Institute, Judge E. H. Gary, and Maj. Gen. George W. Goethals; the stirring calls to duty by John A. Topping and a number of impromptu speakers, and the wartime flavor of one or two of the leading technical papers.

The morning session was opened by Judge Gary's address immediately following the registration of the members, the remainder of the morning session and the afternoon session being devoted to the reading and discussing of technical papers. The usual banquet was featured by stirring speeches.

Richard H. Rice, engineer, General Electric Company, West Lynn, Mass., read the first paper, during the day sessions, on "Recent Installations of Large Turbo Generators," which was discussed by Dr. David S. Jacobus, advisory engineer, of the Babcock & Wilcox Company, New York. Another discussion, written by Alexander Dow, president of the Detroit Edison Company was read by Prof. C. R. Hirshfield in Mr. Dow's absence. The paper on "The Manufacture of Steel Castings," read by Robert J. P. Lamont, president, American Steel Foundries, was discussed by R. F. Flinterman, president, Michigan Steel Castings Company, and by S. P. Buck, president of the Buckeye Steel Casting Company, Columbus, Ohio.

The first paper of the afternoon session, "The Relative Merits of Forming Steel by Pressure, Hammering or Rolling" presented by John Lyman Cox, engineer, Midvale Steel Company, Philadelphia, Pa., was discussed by E. O'Connor Acker, Bethlehem Steel Corporation, Bethlehem, Pa. Following this discussion Dr. Wm. O'Neill Sherman, general surgeon of the Carnegie Steel Company, Pittsburgh, read an interesting paper on "Surgical Discoveries of the War and Their Application to Industrial Accidents; Humanitarian and Economic Features" describing the new methods of treatment of infection and burns discovered by Dr. Alexis Carrell and Dr. H. D. Dakin, working under the auspices of the Rockefeller Foundation in France.

Walther Mathesius, superintendent of blast furnaces of the Illinois Steel Company, South Chicago, presented the closing paper of the afternoon session on "The Chemical Reactions of Iron Smelting," which was discussed by H. B. Howland, superintendent of blast furnaces of the Wisconsin Steel Co. Mr. Mathesius' paper is reported elsewhere in this issue.

Government Is Coöperating With Business.

The opening address of President Gary, stating unequivocally the position of the iron and steel industry in its relation to the government in the present war crisis, received the most favorable comment at the hands of the country at large. Following a masterly summing up of the events that led to America's declaration of war, and a frank reference to the difficulties that confront the country, Judge Gary proceeded:

> The task which confronts the country is not confined to the army and navy, although they will be entitled to the larger part of the credit and glory if we succeed. They offer their bodies as a sacrifice, and they must have the undivided, unqualified support of all outside their ranks. The pecuniary burdens to be imposed upon us will be very great. We knew in advance such would be the case. We must pay the enormous cost of mobilizing, equipping, supplying and moving our own armies; and we must advance money and provide supplies to our Allies in accordance with their necessities and our resources. We could not decline if we were disposed, for they are now fighting our battles and we are, with them, under the whole burden.
>
> Some of us are complaining or criticizing because of the enormous taxes that are likely to be imposed. We are apt to consider ourselves as opposed by the legislative or executive departments of the Government, as if they were partisans, seeking to punish or at least unfairly treat the private individual. We do ourselves an injustice by harboring such thoughts. We can rightfully claim that the burden of taxation be equitably distributed; that all the people, after exempting the necessities of life, shall be compelled to contribute; and that there shall be no waste or extravagance in making expenditures. Taxes ought to be levied and distributed if possible so as to avoid clogging the channells of business prosperity. All this we may properly demand. Equitable distribution is fair and reasonable, and it makes all pecuniarily interested in the subject, including

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both the collection and the expenditure of the taxes levied. Less than this would tend to create classes—the worst thing for any country.

Now is the time to unite the whole country in a common cause. The soldiers are on a level as they ought to be. All others should be on a level. Classes should be obliterated and also politics, localities and religious differences during war times at least. Opportunity should be open to all; governmental burdens should be borne by all. With such an administration of governmental affairs we should be satisfied, however severe the drafts which are made upon us or upon the larger interests which we represent.

I lately spent a few days in Washington, and it was my privilege to met a number of men who in legislative halls or executive departments are serving their country; and it is certain that all are actuated by the motive to fairly represent and protect the best interests of the country and all the people. Individuals are not influenced by politics. There are and will be differences of opinion concerning the various questions presented as a matter of course, but these will be adjusted and the legislation finally passed will represent an honest endeavor to do what is proper.

Government is Coöperating With Business.

You have heard some criticism concerning the conduct of the Government's business affairs. It has been said that confusion or at least lack of system or coöperation sometimes appears; but it must be remembered that there has been suddenly thrust upon the Government officials an enormous amount of business, extraordinary in volume and character, and the strength and capacity of all are taxed to the utmost and often beyond physical endurance. Besides, rules of law or of departments established to fit other conditions sometimes appear and prevent the exercise of judgment which would bring better results if more latitude were permitted. Officials in Washington are entitled to credit and praise for their management under existing circumstances, and so far I believe there is no just ground for severe criticism.

And then there is a disposition on the part of Government officials to coöperate with the business men in promoting the welfare of the country. This is what all of us have desired and advocated, and now we will probably have as much opportunity in this direction as we have ever desired. Just what will be the result in all the ramifications of the business involved remains to be seen. To the extent that the Directors of this Institute have been personally connected with these matters they have been well satisfied, except perhaps as to some of the prices in question.

Mr. B. M. Baruch, Chairman, Committee on Raw Materials, Minerals and Metals of the Advisory Commission of the Counsel of National Defense, writing for himself and the Secretary of War, and also representing the Secretary of the Navy, requested your President to act as Chairman and to appoint other members of a committee on Steel and Steel Products, to coöperate with the Government; whereupon the matter was brought before the Directors of this Institute and such a committee was designated, consisting of the following:

Elbert H. Gary, chairman; James A. Farrell, vice-chairman; James A. Burden, E. A. S. Clarke, Alva C. Dinkey, Willis L. King, Charles M. Schwab, John A. Topping.

The General Committee has appointed sub-committees as follows:

For Ascertaining Capacities and Supervising Allotments of Orders to Manufacturers:—James A. Farrell, E. A. S. Clarke, J. A. Topping, E. H. Gary, ex-officio.

On Alloys:—J. A. Farrell, E. A. S. Clarke, A. A. Fowler, E. G. Grace, E. J. Lavino, E. H. Gary, ex-officio.

On Iron Ore, Pig Iron and Transportation:—H. G. Dalton, Frank Richards, Harry Coulby, George T. Dyer, W. T. Shepard, A. H. Woodward, Leonard Peckitt, Frank Billings, Amos Mather, secretary.

On Sheet Steel:—W. S. Horner, Charles Hadley, Walter Carroll.

On Scrap Iron and Steel:—Eli Joseph, Samuel Deutsch, Vernon Phillips, Joseph Michaels.

On Pig Tin:—John Hughes, E. R. Crawford, Edwin Groves.

On Tin Plate:—J. I. Andrews, E. R. Crawford, E. T. Weir.

The committees meet regularly and are devoting much time to the work involved.

The Iron and Steel fraternity, represented by this Institute, will be actuated by the highest conception of patriotic duty with respect to the requirements of the Government. We will cheerfully bear our full share of the load which must be carried until there is realized a complete triumph over the hosts of aggressive, desperate and inhuman autocracy. Personal interests will yield to the necessities of the country we love.

At the closing banquet, General Goethal's frank statement of the shipping situation, speaking on behalf of the government, roused an instant response from those present. In part, General Goethals said:

Goethals' Statement

As I need assistance and coöperation in my work, I concluded to tell you my troubles and ask your help. On the principle of the selective draft, I have again been called to the Government's service and confronted with the proposition to turn out 1,000 3,000-ton wooden ships in 18 months; wood, because it was not possible to get steel and because they could be constructed in less time.

I found that contracts for wooden ships had been let in all directions, but was unable to find plans or specifications. When you consider that the birds are now nesting in the trees that will go to build those ships—ships that must attain a speed of 10½ knots and several additional knots to escape submarines—why, the proposition is simply hopeless.

I called on Mr. Farrell of the United States Steel Corporation and I asked him if it was not possible to turn to steel. He assured me it would be possible. I announced it and I asked permission to turn to steel as well as wood. I finally got permission. Fifty million dollars were appropriated for these ships from the sale of Panama Canal bonds, but no effort has yet been made to sell those bonds. Money is as necessary as anything else.

This is now being discussed in the House Committee on Appropriations and I have been promised the money in ten days or two weeks.

I had a second conference with Mr. Farrell and he promised to see the program carried out if we turned to steel, and he promised also to turn out 3,000,000 tons of steel ships in 18 months.

As the shipping built will ultimately go to the merchant marine, if they escape the submarine, they should be as far as possible of steel construction. I want the institute to get back of Mr. Farrell and to carry out the promise.

The ship yards are full. I have asked for legislation to prevent the laying down of ships for anyone but for us. I want to enlist the coöperation and assistance of the structural steel people. I have got to have the coöperation of manufacturers, makers of machinery. chains, wire cables, in fact, everything that goes to make the complete ship, and if what Lloyd George said is true, that ships are going to win the war, everybody who helps build ships will help win the war.

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The Manufacture of Steel Castings*

Rapid Development of the Art of Forming Large Castings—Problems of Design and Treatment Briefly Sketched—Use of Acid and Basic Steels—Shrinkage, Porosity and Annealing Difficulties.

By ROBERT P. LAMONT,
President, American Steel Foundries, Chicago.

In the Proceedings of the American Iron and Steel Association (as it was then called) for the year 1883 it is stated that "included in the production of open hearth steel ingots in 1883 are 1,684 net tons of steel castings made directly from the open hearth furnaces. The production of steel castings is rapidly increasing in this country." From year to year since then the annual figures have been given, but as far as we can find there have been no papers on the subject, so perhaps to begin with a brief statement outlining the history of the industry may not be out of place. In so far as we could find, no one in this country has undertaken to record its early history or to keep any record of its development.

Every ton of steel produced by present methods may properly be called cast steel, but only a comparatively small percentage of this steel in its final form may be correctly described or referred to as steel castings. There would seem to be a rather small margin of difference between pouring the molten metal into an ingot mold preparatory to its being rolled or forged, and pouring the same metal into a mold in which it takes its final form and shape. Looking at it now, it doesn't seem as if it should require any great inventive skill to step from one process to the other. In principle it is a simple matter, but the practical difficulties were great and the

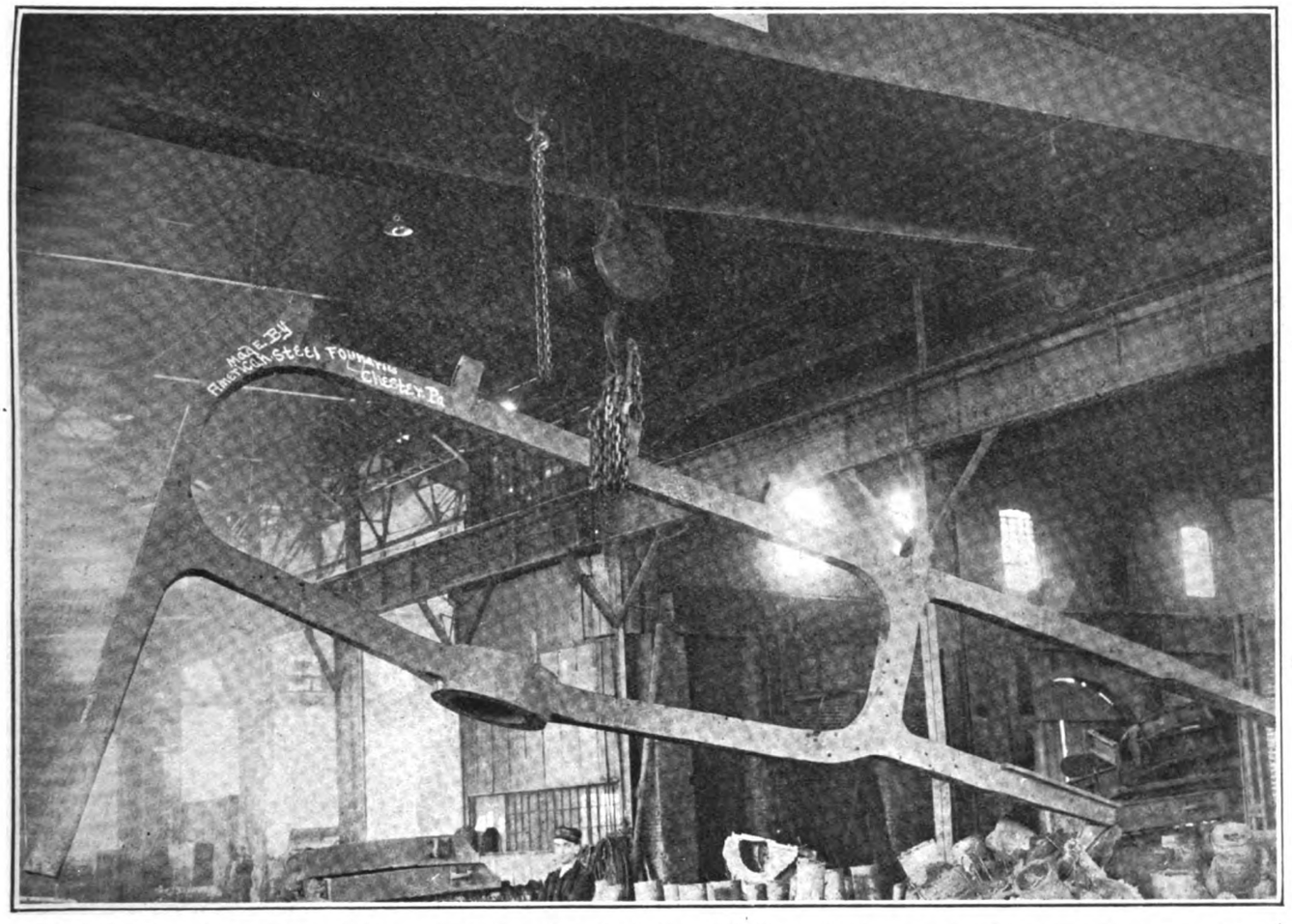

Fig. 1.—Stern frame for Munson Steamship line, Weight, 22,984 lbs.—Thurlow works, American Steel Foundries.

* From a paper presented at the New York Meeting, American Iron and Steel Institute. The first part of the paper, which is entirely historical, is omitted from this report.

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development of the cast steel industry was correspondingly slow.

At the Chicago Exposition in 1893 there were exhibited by Krupp some steel castings which at that time were considered very remarkable, among them being a cast steel frame for a Pennsylvania Railroad locomotive. At a meeting of the American Society of Mechanical Engineers at the time, doubt was expressed as to whether any American steel foundry could make such a casting. A contrary opinion was expressed to the effect that possibly three or four steel foundries in this country could make such a casting, but that probably several castings would be lost before a successful one could be produced. Stimulated possibly by this exhibit and by the growing demand, American manufacturers soon demonstrated their ability to make these frames, for five years later they were being generally used. These first frames were light and of simple design, as compared with those now made every day as a matter of ordinary routine. At the present time frames are not infrequently thirty-four feet long, and weigh up to 14,000 pounds. The percentage of loss in a good foundry does not exceed four.

Development During Recent Years.

During the past twenty years the development of the steel-casting industry has been steady and rapid, although, of course, the production has had ups and downs following general business conditions. Beginning with the nominal production of 1,684 tons in 1883, by 1897 the production had increased to approximately 100,000 tons. To-day there are about two hundred steel foundries in the country, with a total rated capacity of approximately 2,000,000 tons, though the actual production given for last year was probably about 1,500,000 tons. The exact figures are not yet available.

Of the approximately two million tons capacity of steel castings in the country to-day about 52 per cent is for basic and 48 per cent acid steel. Almost 90 per cent is produced in open hearth furnaces; 8 per cent in the converter; and the balance crucible and electric. We have no accurate figures showing a division of tonnage as between dry and green sand molds, but the figures are probably not far from 60 per cent green sand and 40 per cent dry sand.

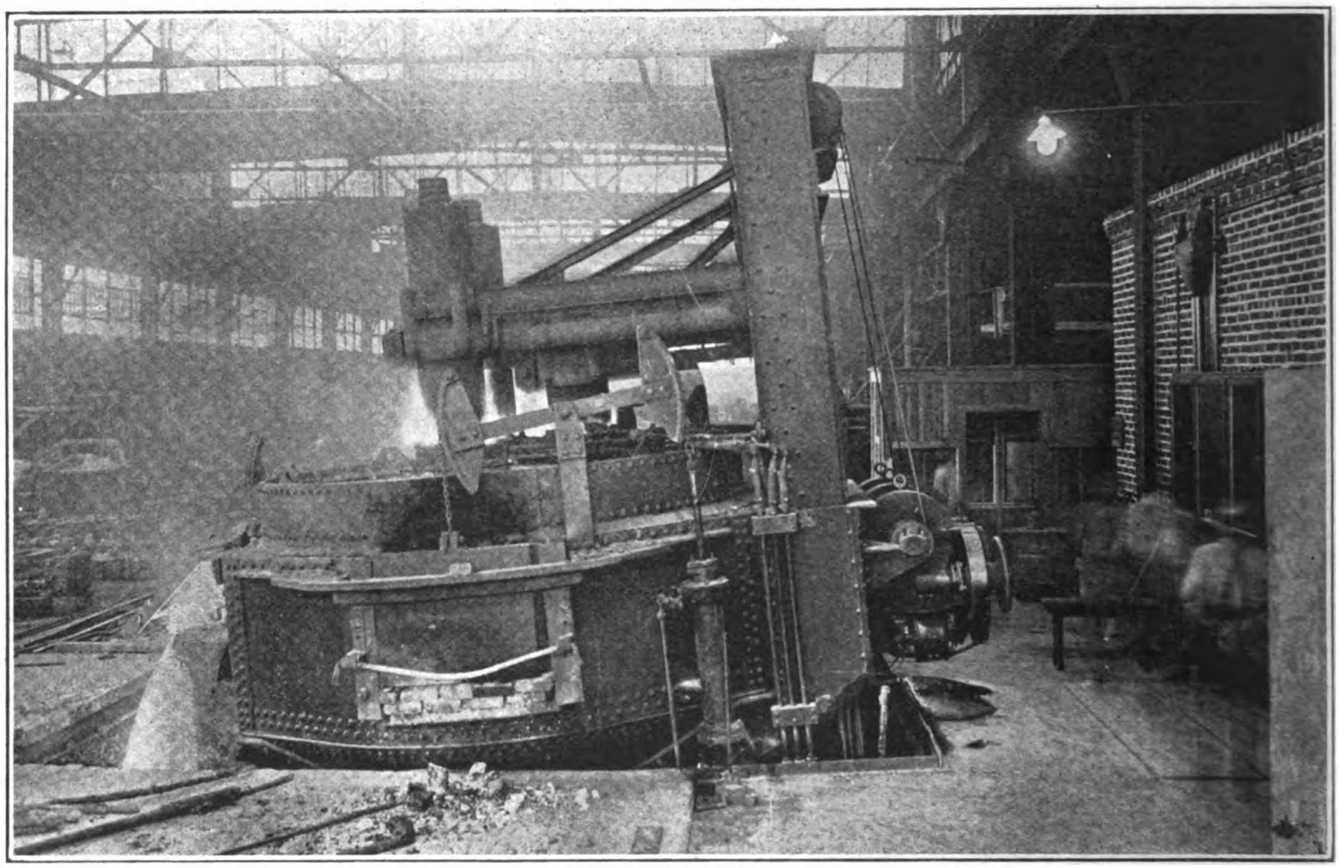

Fig. 2.—Six-ton Heroult Electric furnace, Indiana Harbor plant, American Steel Foundries.

A comparatively recent important development in the industry was the coming in of the electric furnace. If it has not already done so, it will entirely replace crucibles and converters as a means of melting. Steel melted in the electric furnace can be brought to almost any state of purity desired, and a very high temperature can be secured. The electric furnace will produce steel of as good quality and at lower cost than the crucible, assuming, of course, a reasonable price for current and sufficient demand to take the output of the furnace.

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It is not necessary here to describe the difference between the acid and Bessemer methods, but it might be well to say that practically all machine castings—castings requiring any machine finish—are made of acid steel, while all miscellaneous car castings, such as bolsters, side frames, center-plates, couplers, etc., which do not require machining, are made of basic steel and in green sand molds.

Acid steel castings, particularly if made in dry sand molds, present, as a rule, a better external surface and are freer from pinholes and surface defects. When you get below the surface, however, a test of basic steel will show just as good physical properties as the acid steel. The production of acid as compared with basic steel is less complicated from a mechanical standpoint, and is rather more generally susceptible of control in the matter of soundness or freedom from blow-holes. The fact that it takes about an hour, as a rule, to pour an average heat into steel castings, means, of course, that the slag is in contact with the top of metal in the ladle just this length of time, and the basic slag takes up the silicon from the steel and in return gives up substantial amounts of phosphorus with the result that the last metal to leave the ladle is inclined to be "wild," resulting in porous castings, and sometimes a rather high percentage of phosphorus. This difficulty is not met in the acid steel.

There is, I think, a somewhat mistaken impression as to the difference in cost between acid and basic steels. At the present time low phosphorus pig, which is used in the acid process, is selling for about $75 per ton, and low phosphorus scrap $40 per ton, while basic pig is, say, $42 at Pittsburgh, and heavy melting scrap about $32. Taking into account simply the difference between these figures, apparently the acid steel would be very much more expensive than the basic. However, when account is taken of the fact that a much smaller percentage of pig is used in an acid heat than in a basic heat—that the melting time is considerably shorter, the melting loss being about 2½ per cent of the metals charged, and the life of the furnace substantially longer—the difference in cost is not great. At the present time, taking all factors into account, I should say that in the Chicago territory, for instance, the difference in cost is not more than $2 per ton, in favor of the basic steel.

Dry Sand and Green Sand Molds.

The so-called dry sand mold is made of a mixture of silica sand and fire clay, modified in some cases with small percentages of rosin, dextrine or flour. After the mold is finished it is dried in an oven, which is kept at a temperature of about 500 deg. F. for from six hours to six days, depending upon the volume of sand to be dried. This drying process, of course, ties up a large amount of flask equipment, requires a great deal of fuel and extra handling, and adds at least $1.00 per ton to the castings over the green sand method. In the case of large, rangy castings, such as stems, stern posts and rudders for battleships, the molds have to be rammed, then split up into sections, which are dried separately, and finally fitted together on the dry floor before the casting is poured. Under ordinary conditions such a mold is in process of construction ten days to two weeks before it is ready for the metal. In the case of the steamship Prinzess Irene, which went aground on the shore of Long Island, April 6, 1911, the Steamship Company was anxious, of course, to get the vessel back into the service as promptly as possible, and offered a liberal bonus for the completion of a new sectional stern frame in less time than was usually taken for such a casting. The record in this case was eleven days, and the bonus earned was almost equal to the price of the casting.

Green sand is composed of silica sand and silicious fire clay, in the proportion of about one clay and ten

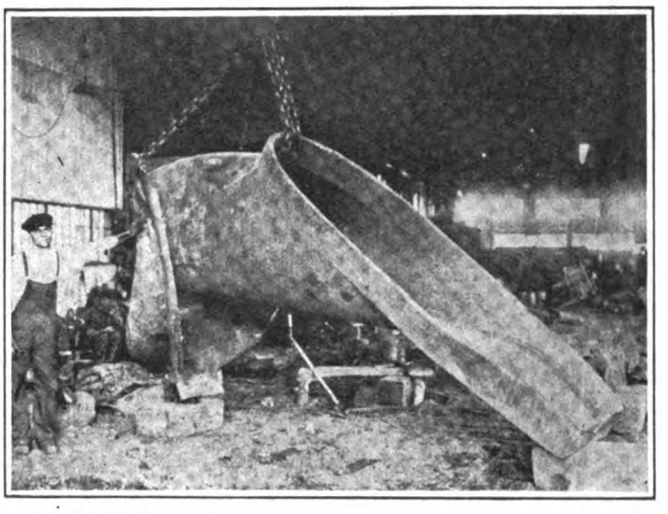

Fig. 3.—Hawse pipe for Battleship Mississippi, weight 12,930 lbs.

sand, all thoroughly bonded in a heavy sand mill. These molds can be filled immediately after they are prepared—in fact, the sooner, the better, for if they are allowed to stand unusually long, the cores take up considerable moisture, and in dry weather the sand mixture tends to lose its bond and disintegrate.

On account of the length of time it takes to pour an ordinary ladle of steel into castings, and because also many castings have thin sections, it is necessary to have a metal temperature at the time the heat is tapped of about 2,800 deg. F. The melting point of silica sand is about 3,200 deg. F., so that the margin between the temperature of the steel and the melting point of the mold is rather narrow. As a matter of comparison, the pouring temperature of gray iron is from 2,200 to 2,300 deg. F., and of malleable iron from 2,300 to 2,400 degrees, which is well below the melting point of the mold, and the sand is not seriously injured; whereas, in a steel foundry the facing sand, so-called, which comes in contact with the hot metal a few times is practically destroyed, and can thereafter be used only for backing.

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In green sand work about 1,500 pounds of new sand is required per ton of castings, and in dry sand the average is a ton of sand to a ton of castings.

Obviating Cracks, Pipes and Blow-holes.

The next great difficulty which confronted the manufacturer of steel castings was to avoid shrinkage cracks. The contraction of cast steel is about seven thirty-seconds of an inch per foot—practically double that of cast iron. To get an idea of what this means, a locomotive frame thirty-four feet long, for instance, will shrink or contract six or seven inches in length in cooling from a liquid to a solid state, and provision, of course, must be made to allow this contraction to take place. A long, slender section of a casting, with flanges or projections at both ends, will invariably crack, and in extreme cases pull itself apart, unless the holding power of the mold against these flanges or projections is removed in time. It is important in the designing of steel castings to avoid, wherever possible, such a condition as this. It is equally important to avoid a sudden change from a heavy to a light section.

Another great difficulty with the proper production of steel castings is the avoidance of pipes and shrinkage cavities. This can be done only by the use of risers or shrink heads of sufficient size and number and properly located. In extreme cases the weight of metal in these risers—which must, of course, be cut off—equals the weight of the casting itself, and the average of net production of castings probably is not over 65 per cent of the metal charged. In green sand work, where the sections are thin and heavy risers not used, the yield may in some cases run somewhat over 75 per cent. The cost of cutting off these risers, and the fact that to produce a ton of castings requires from a ton and a half to two tons of metal, is a very large item in the cost of steel castings. In the last few years the use of gas cutting torches has greatly facilitated this work.

Another difficulty which has long been difficult to overcome, the one which perhaps more than any other has been the cause of a good deal of the unfortunate reputation steel castings had in the earlier stages of the development of the business, was porosity—blow-holes, so-called. There are many causes for this condition, among the principal of which are: Improper composition of metal, wet sand, too much carbonaceous material in sand mixture, poorly ventilated cores, rapid filling of the mold, improper gating. The truth is that the proper making of a steel casting calls for the coördination of a good many elements and compositions; if any one is imperfect, the effect is sure to be seen in the casting. And the difficulty is that in the handling

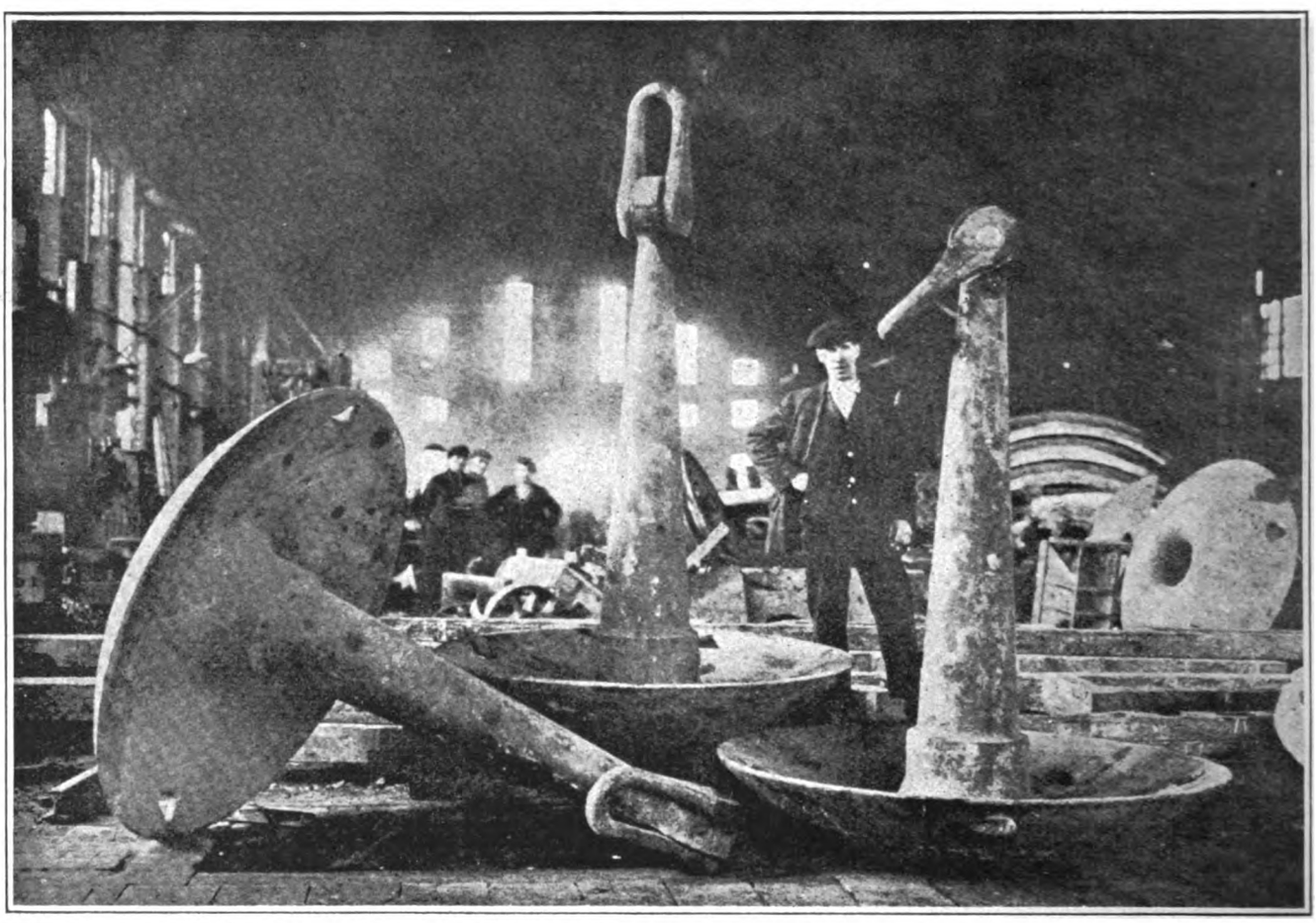

Fig. 4.—Mushroom anchors, government lighthouse service, weight 5,000 lbs.

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of certain of these elements, no rules can be laid down which will satisfactorily guide an inexperienced man. Skill based on long experience is the only apparently sure guide.

Need of Annealing.

Then, after the casting is all but finished, it must be annealed to relieve possible internal strains due to irregular shrinkage in the casting itself, and the different rates of cooling due to variations of sections, etc. There has been a great deal of difference of opinion on this matter of annealing. Some makers have gone so far as to claim that it was not necessary. A paper could be written on this subject alone. Our experience is that annealing is necessary; certainly it is in the direction of safety. The proper annealing temperature depends upon the carbon contents of the casting, and ranges from about 1,300 to 1,500 deg. F. for carbons from .20 to .90.

So much for the mechanical and manufacturing features of the business. The past history of the industry has been about the same as that of most industries. The early experimental and development stage was difficult and unprofitable. In course of time a few successful businesses were developed and made money. After that there was apparently a too rapid expansion of capacity, excessive competition and no profit. Then followed the usual dropping out of the weak and the building up of the strong companies. During recent years, when general business conditions have been good, I think the industry as a whole has shown a fair margin of profit. Following policies and methods suggested and practiced by this Institute, the larger companies have been more inclined to work on a "live and let live" basis. We have been exchanging information as to methods, comparing costs, and undertaking in certain

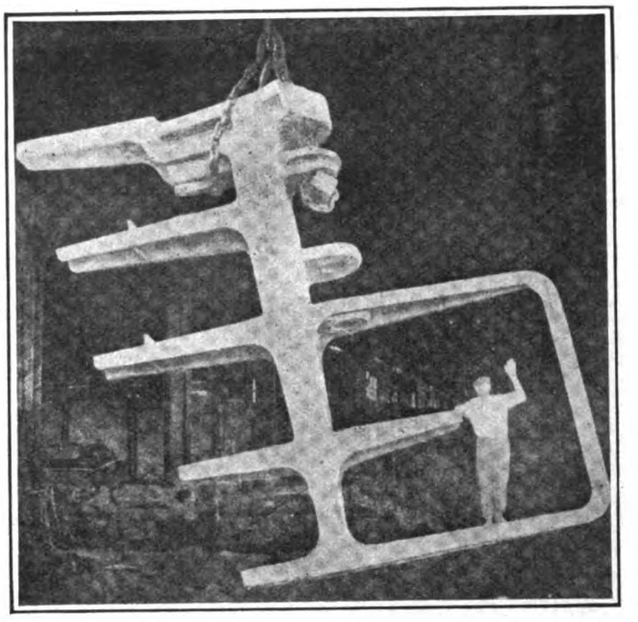

Fig. 5.—Cast steel rudder frame for Battleship Mississippi, weight 50,500 lbs.

directions to adopt standard designs and specifications, all with the idea that by improving our methods and reducing our costs, we will broaden the field of the industry and make more work for us all.

Discussion: The Manufacture of Steel Castings

By S. P. BUSH, President, Buckeye Steel Castings Company, Columbus, O. — It is true as Mr. Lamont says that castings produced by the acid process are generally regarded as less subject to certain disadvantageous elements such as porosity, but this is not to say that castings made by the basic process can not be produced of equal quality in every respect with those made by the acid process. As an illustration of this I might say that some years ago when the manufacture of large steam turbines was in process of development it was thought that the frames or discs could not be constructed otherwise than by building up with rings, inasmuch as complete freedom from such defects as porosity was required, in fact, entire absence of any doubt as to the reliability of the structure was required. The production of these frames or discs was undertaken by one steel castings concern with this requirement in view, and in a comparatively short time these parts were produced by casting to the entire satisfaction of the turbine builders.

To-day these parts are produced by no other method than by casting, and quite as often by the basic process as by the acid. As to the structural value of steel castings, it is only necessary to point out that such a structure as a car or locomotive truck must necessarily be greatly improved by the great reduction in the number of parts required to make a complete structure. Further than this, the casting has a great advantage in effecting a reduction in weight varying from 20 to 50 per cent.

Mr. Lamont has spoken of removing internal stresses, and in this connection it may be interesting to point out that in the case of such a piece as a locomotive driving frame, it is generally conceded that as compared with a forging, the chances of internal stresses remaining in the structure after finishing are generally regarded as considerably less. The term annealing as applied to castings is often a misnomer. In most cases the annealing process is nothing more than a heat treating process by which the structure of the steel is changed. It is yet something

(Continued on Page 257.)

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*Relative Methods of Forming Steel by Pressing, Hammering or Rolling**

Comparative Data on Effectiveness and Quality of Product in Very Heavy Work, With Hammers and Presses—Limitations of Each Process, Under Present Practice—Special Equipment Would Make Rolling Possible in Much Heavier Work.

By JOHN LYMAN COX,
Engineer, Midvale Steel Company, Philadelphia.

The principal conditions upon which the physical properties of steel depend are composition, process of melting, care in melting, design and character of ingot mould, conditions of pouring and of cooling, temperature and time of reheating, amount and character of hot working, finishing temperature, final section, subsequent treatment, and the manner of testing.

A well-melted and well-poured steel is one containing a minimum of undesirable inclusions. These inclusions comprise slags, oxides, bits of brick and other adventitious matter, imperfectly-melted alloys, blow-holes,—which usually contain a droplet of slag — and shrinkage cavities, fissures, or lines of weakness—either primary or secondary; to which, classifying it by some of its effects, might be added the size of ingot crystallization.

Under the influence of mechanical working the inclusions flow in the direction of the flow of the surrounding metal, forming solids or surfaces of cleavage whose influence upon the physical properties of the steel, as shown by bending and tensile test bars, is vast. Defects running lengthways of a test bar act chiefly as slightly decreasing its effective cross-section. Transverse defects are wholly different; a thin film of slag may almost cut a bar in two.

Considerations in Test Bars.

Whenever circumstances permit, a careful engineer lays out his test bars on a piece in the direction in which it will be chiefly stressed in service. Thus, for bolts or axles, the tests should be longitudinal; for rotor shafts, with longitudinal slots to hold coils, radial tests might with propriety be asked; forgings for guns or other pieces subjected to internal pressure should be tested transversely; shell base-plugs should be tested longitudinally.

Often it happens that the stresses in an engineering member are not chiefly in one direction. Thus, a steel plate is usually rolled crosswise and cornerwise before being given its final length, while the belief is general that a forged axle, kneaded back and forth under a hammer or press, is superior to one rolled—with the work all in one direction.

Were steel wholly free from inclusions, or defects which act as such, and were it always given a heat treatment which would break up the slight elongation of the grains in the direction of working, the physical properties would be equal in all directions—and occasionally such a piece is found. Unfortunately the contrary is almost universally the rule.

The function of hot working is twofold,—to bring the ingot to the dimensions desired in the completed article, and to break up the coarse structure of casting. The final fine grained structure in turn is dependent on a proper heating both as regards time and temperature, to break up the ingot structure, and upon a thorough working, during cooling, to complete this grain refinement,—a working continued to a temperature throughout which will not allow much grain growth when it is ended. I see little advantage in a great amount of hot working above what is required by these considerations, and much against it. Excessive reduction means larger ingots to start with; larger ingots mean more internal troubles, and more internal troubles mean poorer quality of product.

Early Hammer Installations.

It is generally understood that a forging press costs about as much as an equivalent hammer with its foundations. A well designed press uses probably not one-third the steam consumed by the hammer; its tools are lighter and more convenient, being free from shock, and there is much less breakage. In most cases the output from a hammer is less than from a press, but when used cogging down ingots for subsequent rolling, the press cannot compete with the hammer, even though it be equipped with power handling devices.

In 1882, when the Midvale Steel Company took its first order for 6-inch Navy Rifles, its forge shop was equipped with Morrison type hammers, the largest being a 10-ton double-acting hammer with 35-inch steam cylinder and 6-ft. 6-in. stroke. The tubes were made from 25-in. octagon ingots reduced to 13-in. rounds tapered to 11-in. at the muzzle, and the packet from 30-in. squares reduced to about 17½-in. rounds. For

* Abstract of paper presented at New York meeting of American Iron and Steel Institute, May 25.

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these operations the hammer had sufficient power, although the cogging of a 30-in. square to a 20-in. octagon was a slow proceeding. In 1885 the Company took an order for a short 8-in. Rifle for the Army, the packet of which had to come from a 38-in. octagon. That increase of 8-in. overstepped the boundary. Although in time the gun was finished, the 38-in. ingot was clearly beyond the proper range of the 10-ton hammer.

With the increase in size of naval guns a heavier tool became necessary and in 1888 the Midvale Steel Company began the erection of a 25-ton double-acting hammer with 50 in. cylinder and 9 ft. 6 in. stroke, built by the Morgan Engineering Company from designs by the late Frederick W. Taylor. This tool was probably the most effective hammer ever built. The forging was controlled entirely by power. The ingot was brought from its heating furnace to the hammer with the free end of its porter-bar fastened to a trolley in an underground conduit. When the ingot was landed on the die, the trolley was disconnected and on the porter-bar was thrown a heavy ring connected by a wire rope to a horizontal underground hydraulic cylinder which did all the weighing-on of the usual crowd of men. The 60-ton traveling forge crane rotated the piece on the die and the overhang was sustained at first by a gantry, later by a 25-ton traveling crane.

With this powerful tool 13-in. gun forgings were made in quantities from ingots as large as 63-in. octagon, in spite of predictions to the contrary, and with excellent results.

The largest hammer ever built was the 125-ton single-acting hammer of the Bethlehem Steel Company, intended for the forging of armor plate. Both it and the 25-ton double-acting hammer of Midvale, really a 75-ton as compared with a single-acting hammer, have been abandoned for forging presses.

Hollow Forgings.

With the exception of the tube, which is generally made solid, the larger forgings for heavy artillery are usually made hollow, as are marine shafts and other forgings when desired of especially high quality. As it is difficult to manipulate under a hammer, in upsetting and punching, blocks too heavy to be handled on levers, it is customary to bore the ingot with a hole of suitable size and cut from it a hollow block of proper weight for the job. The hole in this block must be larger than the mandrel upon which the block is to be forged, involving great waste of metal if the mandrel be large. To avoid this waste, and in the case of gun forgings to assist in the proper direction of the contained imperfections, the billet is first bored with a smaller hole, then hung upon a mandrel suported at each end in a housing die-keyed on the anvil block in place of the bottom die, and by blows upon the periphery as the billet is turned upon the mandrel its walls are thinned and the interior diameter increased until it is of the desired size. It may then be placed upon a drawing mandrel of the proper diameter for the final bore and drawn out in a V-die to the desired exterior form and size, if required.

The width of a hammer anvil block is not great and if the forging be heavy it is in practice necessary to use an ingot of initial section sufficient to give the requisite weight in the short length that will go between the checks of the mandrel housing, for upsetting of heavy blocks under a hammer is impracticable, as previously stated. The employment of ingots of large cross section being objectionable for reasons already given, as also because of the added dangers in cooling and reheating and in the time consumed

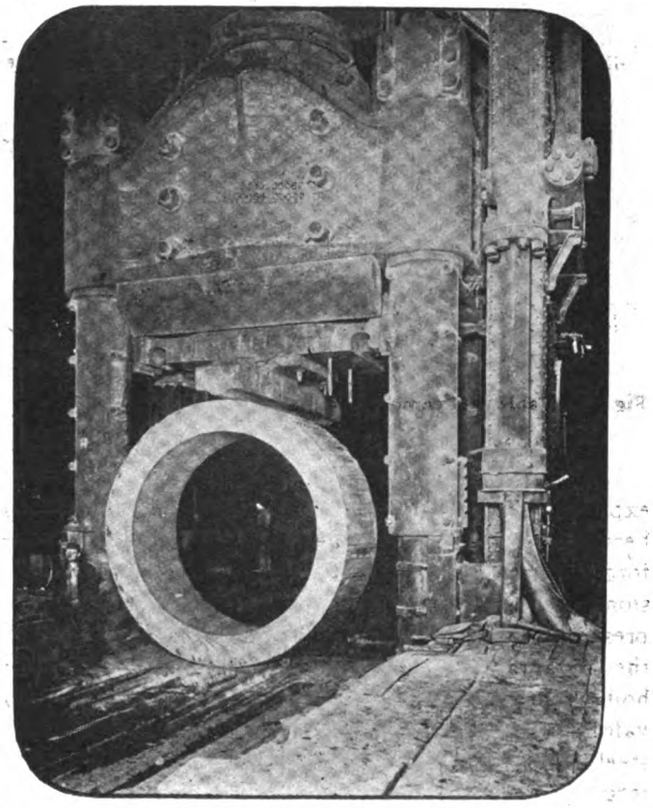

Fig. 1.—Large drum expanded under 10,000-ton pressure; Midvale Steel Company.

thereby, we have here one weakness of the hammer, It cannot make the great hollow forgings easily producible under a press, such as the drum illustrated in Fig. 1.

It might be urged that an anvil of a special design would permit the use of long billets of less diameter, but a long unsupported mandrel will not withstand the impact of hammer blows. So little time is given for the flow of the hot metal that the force of the impact is transmitted in large part directly to the mandrel, which breaks. A 14-in. mandrel on a span of 45 in. to open a hole some two inches, is about the limit for a hammer; a larger mandrel must be substituted as soon as possible.

Hammered Vs. Pressed Forgings.

When made under a hammer of ample power forg-

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ings show test results practically identical with pressed forgings made under the same conditions, so long as neither be expanded. This is shown by the table (Fig. 2), in considering which it must be borne in mind that all the forgings were fully heat-treated by quenching and drawing, which would tend to obliterate any slight differences which might exist in the forgings originally.

Comparative Tests of 12" Rifle Tubes and Jackets Hammered or Pressed from 63" Octagon Ingots Not Expanded.

	C	P	Mn	Si	S	Ni	Cr	Tests after treatment T.S.	E.L.	Ext.	Cont.
12" Tube Hammered 84803	.345	.052	.722	.219	.044	.064	2.96	BC 98500 67000 20.8 32.5			
								BO 92000 61000 20.1 38.0			
								B1 94000 63000 20.5 34.15			
								WC 99500 65500 19.5 4.05			
								WO 99500 67000 21.5 42.85			
								W1 99500 69000 19.0 37.65			
12" Tube Pressed 86886	.400	.047	.705	.201	.048	.038	3.16	BC 97500 61000 18.5 32.5			
								BO 99000 67500 19.0 37.5			
								B1 97500 64000 20.0 33.7			
								WC 96000 66000 21.0 37.9			
								WO 99500 67000 20.5 44.0			
								W1 98500 67500 19.0 33.1			
12" Tube Pressed 87861	.376	.047	.669	.286	.046	.062	2.89	BC 99000 67500 21.0 37.5			
								BO 98500 67500 20.5 41.0			
								B1 97500 67000 20.0 41.1			
								WC 97000 66500 21.0 39.1			
								WO 98000 66500 20.5 47.5			
								W1 99000 68000 21.5 42.5			
12" Jacket Hammered 85973	.432	.046	.638	.213	.029	.051	2.97	BC 102500 71500 19.0 35.8			
								BO 99500 68000 21.0 44.6			
								B1 98000 68000 19.5 46.0			
								WC 101000 69500 21.0 36.9			
								WO 101500 70000 20.0 47.1			
								W1 104500 74000 19.5 47.4			
12" Jacket Pressed 85994	.457	.041	.785	.283	.030	.061	3.38	BC 100500 66500 18.5 30.4			
								BO 103500 71000 19.5 41.0			
								B1 [illegible] 18.0 36.9			
								WC 99000 68000 21.7 38.1			
								WO 101000 69500 20.0 47.1			
								W1 106500 72500 21.5 47.7			

102800 70300 20.0 40.1

102000 68200 20.3 38.6

Fig. 2.—Table of comparative tests—12-in. rifle tubes and jackets.

When circumstances permit an equal amount of expansion, there would be a similarly close agreement between the tests of properly hammered or pressed forgings, but beyond the point where hammer expansion is possible the advantages are altogether with the press. Lest it be thought too much stress is laid upon the advantages of expansion in the manufacture of hollow forgings I will cite an experience of the Midvale Steel Company with jackets for a lot of 12-in. steel coast defense mortars. These were rather short forgings drawn on about a 19-in. mandrel and bored originally with a 20-in. hole. The hole was so small that it had been decided expansion would not pay. As on testing the jackets gave a great deal of trouble, it was concluded to bore the ingot with a 14½-in. hole, expand it on a 14-in. mandrel to 16¼-in. in diameter, substituting a 15¾-in. mandrel and expand on it to 20 in., after which the forgings were drawn in the V-die as before. This expansion of the hole increased the outside diameter by only 1⅝-in., giving that much more reduction in the V-dies to be sure, but the amount of testing was reduced 21 per cent, as an average of 38 forgings of each kind.

The danger in solid hammered work is always that for economy's sake too light a hammer will be used and the forging left with an imperfectly-reduced grain size toward the center.

Forging Pressures.

The pressure produced by a hammer is directly proportional to the effective stroke, inversely proportional to the contract area of the dies and to the distance through which the pressure is exerted, and would be infinity if the distance were zero. The pressure exerted by a press is independent of the stroke, is definite in amount, equalling the net power of the tool divided by the contact area of the dies and the piece being forged. In making round forgings this area is small if the stroke be short and the dies be not deeply buried in the plastic metal, thus permitting a comparatively small press to make large shafts. With a large press excessive die impression will be prevented by fear of lapping; with a smaller press by the die contact area increasing until the press is overpowered and forging ceases. In press forging the work is turned up after every stroke, thus always presenting a new and smaller contact surface.

In cogging down an ingot under a hammer, before rounding up begins, several blows are usually struck in

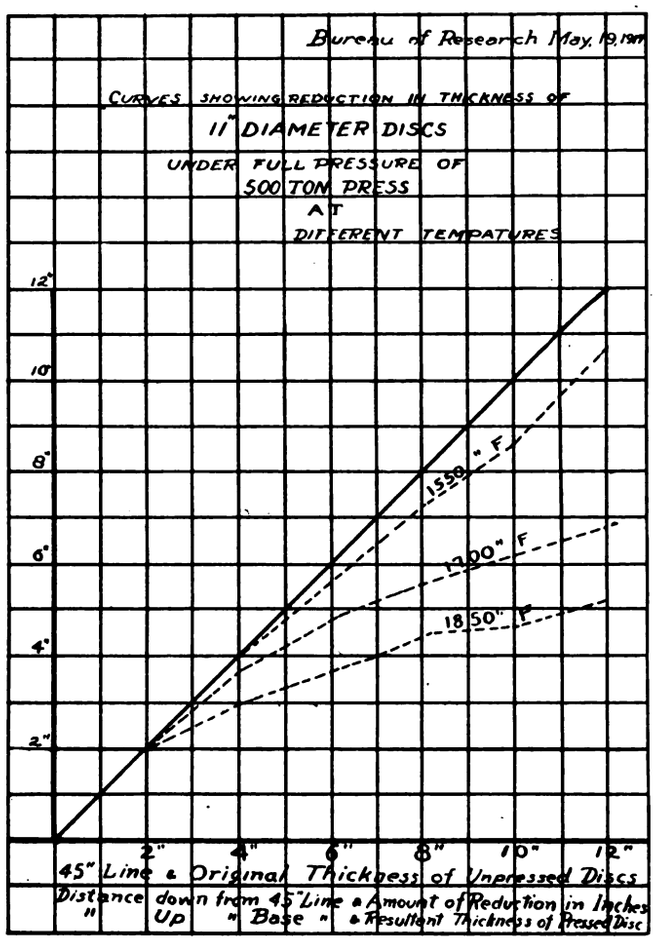

Fig. 3.—Curves of final results, experiments on forging pressures.

the same spot until fear of lapping stops them. Due to the inertia of the part of the ingot beyond the die, at the instant the blow falls there is a tendency to cock up the end of the piece; and the tendency in practice is to let it occur and for the hammer die to cut in more deeply on one side of the ingot than the other, gradually throwing the avis of the forging out of the axis of the ingot. This does not occur under a press. There the

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tendency is for the live die to cut in a little deeper than the head die and bend the piece down; but the piece is revolved after every impression. On plain die work it usually takes a larger press than is generally understood if the finishing temperatures are to be kept low, which is necessary for the best class of work.

The lowest forging pressure per square inch of die contact area of which I know as being effetive was 1.2 tons per square inch, with which it was possible to edge in an ingot 90-in. wide at a full forging heat, and from this the pressure runs up to 13¼-tons per square inch, which it takes to completely fill the sharp corners of moulds for steel wheels.

Limits of Effective Reduction.

Friction between press die faces and their work is very great, while the longer time of contact as compared with the hammer tends to chill the surface of the forging and to prevent flow along the die faces. This results practically in a reduction of the effective thickness of the forging and an increase in the pressure required to forge it. For the metal to escape from the pressure, it must flow from the center outwards between immobile surfaces. The following table gives reliable ratios of thickness to pressure:

	Length		Mean Diameter		Final Pressure per Square Inch Corrected of 2000 lbs. Tons	
	Initial	Final	Contact	Median	Contact	Median
1550°	2	1 63/64	11⅛	11 3/16	5.69	5.62
	4	3 29/32	11⅛	11 23/64	5.63	5.40
	6 1/16	5 39/64	11⅛	11 43/64	6.23	5.66
	8 1/16	7 11/32	11⅛	11¾	5.74	5.15
	10	8 11/16	11⅛	12 3/16	5.96	4.96
	12 1/16	10⅞	11⅛	11 27/32	5.96	5.65
1700°	2	1 31/32	11⅛	11 11/64	6.17	6.12
	4 1/32	3 43/64	11⅛	11 49/64	6.22	5.57
	6⅛	4 27/32	11¼	12 13/16	5.82	3.88
	8 1/16	5 37/64	11 43/64	13 55/64	5.31	3.77
	10	6 13/64	12 1/16	14 53/64	5.06	3.35
	12⅛	6 63/64	12⅜	15 15/32	4.81	3.08
1850°	2	1 15/16	11⅛	11 9/32	6.23	6.06
	4	3 3/32	11 39/64	12 31/32	6.22	4.98
	6 1/16	3¾	12 43/64	14⅝	4.76	3.57
	8 1/16	4 27/64	13⅛	15 37/64	4.28	3.04
	10 1/16	4 19/32	14 9/32	17	3.19	2.25
	11 15/16	5 7/64	14⅝	17 13/16	3.57	2.41

Fig. 3 shows graphically the relative effects of the various thicknesses and temperatures employed in a recent series of experiments. The important influence of thickness is corroborated by two full-sized experiences where, in upsetting at full forging heat a 37-in. octagon slice from 43-in. to 13½-in. in length, it required 8,700 tons which, figured on the areas of the final diameters of 59-in. and 65-in. at the die face and center respectively, gives 3.18 tons per contact inch and 2.6 tons at the center; and in upsetting a 48-in. round 45-in. long to 33-in., where it took only 1.4 tons per suare inch of contact area and 1.3 tons per square inch of median area, on account of the extra thickness of the piece.

Equivalents in Hammer and Press.

The advantages of absence of shock, in addition to the weight to be handled in forging such masses of steel as shown in Figs. 4 and 5 can be readily appreciated, yet in spite of all its excellencies and its adaptability to a wider variety of work, even such as hot planing the defects from heavy armor plate, the press has two failings, both due to its lack of impact: First, it is harder to get rid of scale; second it cannot strike in a mold as large a forging as a hammer its equivalent in other respects. In our experience we consider a 500-

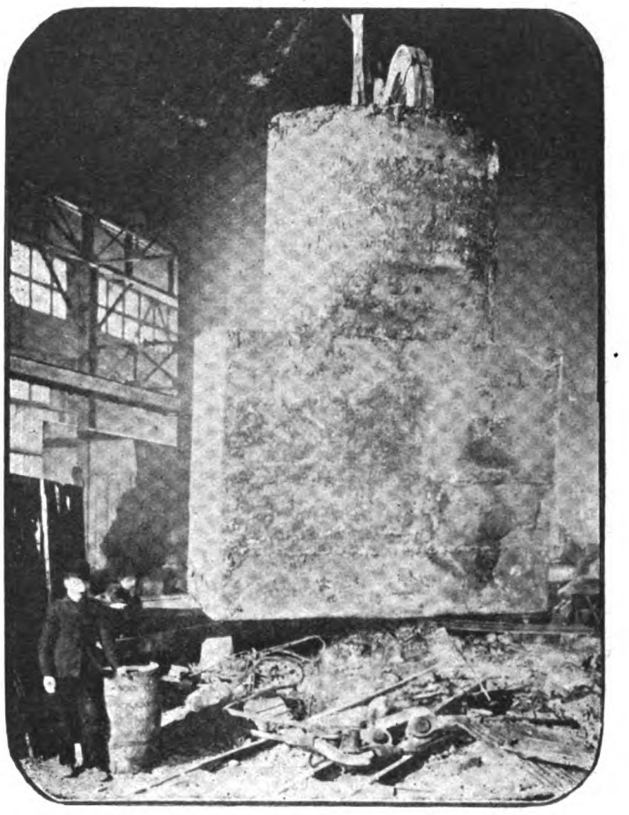

Fig. 4.—A 320,000-pound ingot.

ton press the equivalent of a 2¼-ton hammer; a 1,200-ton press the equivalent of a 10-ton hammer, a 2500-ton press the equivalent of a 25-ton hammer. Yet a 4½-ton hammer can make drop forgings which are beyond the power of a 1200-ton press, and a 2¼-ton hammer can about equal it.

It remains to be said only that in both pressing and hammering the final results depend much upon the skill and good judgment of the forge man.

Some Disadvantages in Rolling.

To institute a comparison between the effects of rolling and the effects of hammering or pressing is much more difficult than to compare with each other the two latter methods. Despite fairly well defined fields, there is a neutral zone in which both operate. Heavy plates are produced both by the press and mill, billets and medium sized rounds, squares and flats, by all three instrumentalities, and small regular sections of tool steel by the hammer and the mill.

The tendency of rolling is to have a more super-

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ficial action than either hammering or pressing; thus to avoid excessive loss through fishtailing the sides of armor plates there is often made a distinct difference between the cross section of the ingot mould for rolling into armor plate and the section used for pressing into the same plate. Under a press the sides of the straight-sided ingot bulge slightly outwards at points about

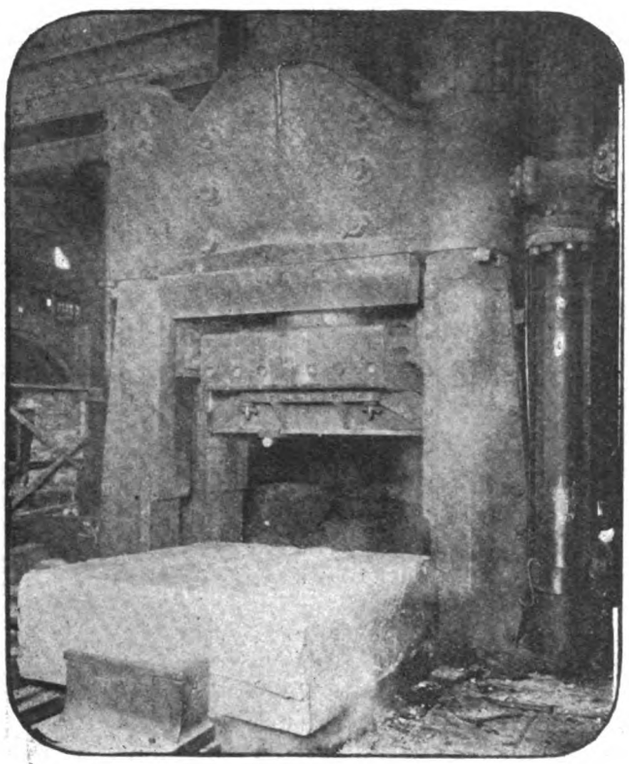

Fig. 5.—Hot-planed armor plate.

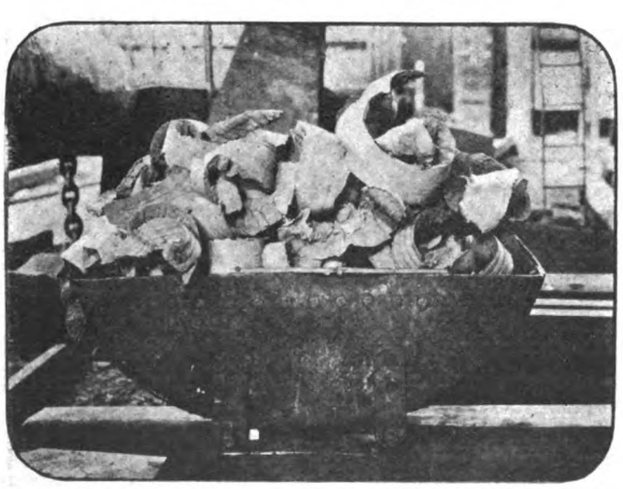

Fig. 6.—Hot-planings from an armor plate.

halfway between the center line and each face but remain nearly straight; between the rolls the center of the diamond-sided ingot stretches very slightly in width but the upper and lower surfaces run out along the rolls, producing approximately straight sides in the finished plate. A straight sided ingot would make a concave-sided plate, if not one actually lapped.

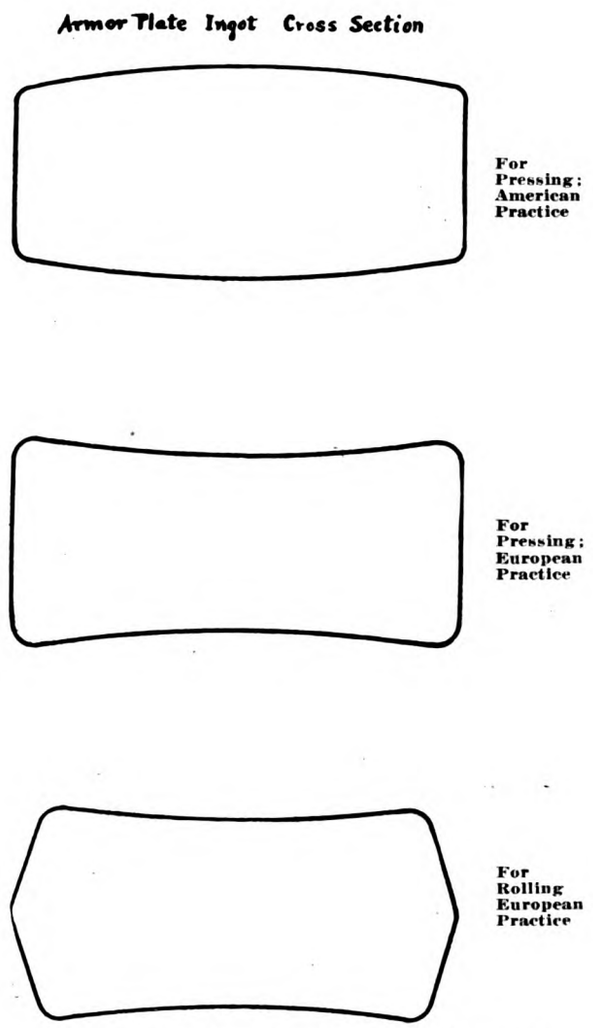

Fig. 7.—Armor plate ingot cross-section.

The operation of rolling is far more rapid than either pressing of hammering with a consequent high finishing temperature. Again, a roll being generally in the condition of a beam supported at each end and loaded at some intermediate point, is much less able to stand high pressures than either a press or hammer and the fear of breaking rolls is always present in the roller's mind,—as well as injury done to the shape of the passes by cool rolling.

Forged Rounds and Rolled Rounds Compared.

The three points just considered constitute, I believe, the reasons for the common inferiority of rolled products. If a heavy mill were to roll its products from ingots at a low initial rolling temperature and finish them at the same temperature as material laid down from a press or hammer, I believe that the difference between rolled and forged products would largely disappear.

A slight evidence of this is shown in the case of a lot of 10⅜-in. rounds, some rolled from 30-in. squares made at one plant, and some forged from 20-in. squares made at another plant. Thirty-six longitudinal test bars, taken on the axial line from 13 rounds

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from each lot and thoroughly annealed, averaged, from the rounds rolled with great reduction, as follows.

		C	Mn.
Tensile strength	88,057 lbs.		
Elastic limit	53,273 lbs.	.43	.70
Extension in 2¾"	21.7%		
Contraction of area	46.5%		

On the rounds forged with a smaller reduction these results were shown:

		C	Mn.
Tensile strength	87,400 lbs.		
Elastic limit	51,750 lbs.	.41	.64
Extension in 2¾"	19.5%		
Contraction of area	40.9%		

Hot-rolling tends to prevent the development of surface defects, but hot-rolled material will not give good results on physical test, hence it is common for rolling mills to refuse orders for billets to show definite physical properties and to insist upon a chemical test only, whereas forged billets are frequently tested physically.

Armor Plate Practice.

Due to the difference between the methods with which they are produced, there is often a distinct difference in the cross-section of rolled and forged plates. Owing both to the rapid cooling of thin plates and to the excessive pressures required for their production

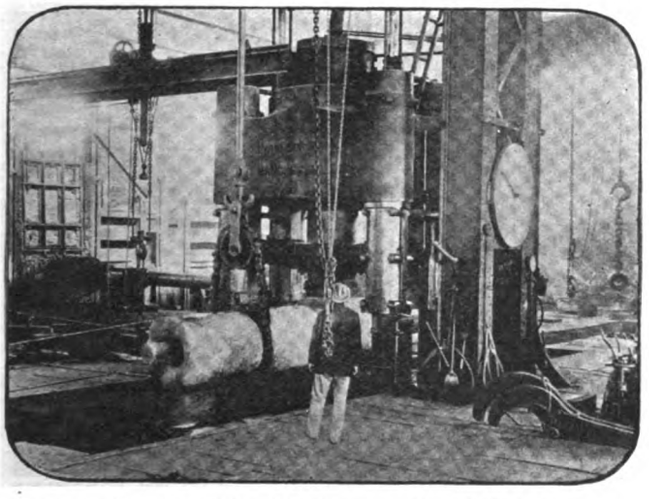

Fig. 8.—Forging 12" rifle jacket under 3,000-ton press.

under the press, it is found that there is a practical limit to the thinness of the forged plates at about 5 in.

In a single cylinder press, the crosshead, being suported only in the center under the ram, is free to bend upward toward the ends, resulting in the plate being thinner in the center and thicker toward the edges; while the rolling mill, with its rolls supported at the ends and free to bend in the center, tends to produce plates thicker at the center than at the edges. This tendency in plate mills is overcome by slightly increasing the diameter of the rolls toward the middle.

In this country all except the thinnest armor plates are pressed, but in Europe, where the demands for armor are sufficiently great to warrant investment in a machine capable of the great output of a mill, armor plates are frequently rolled.

STEEL CASTINGS DISCUSSION

(Continued from Page 251)

of a question whether a casting cannot be produced, which with proper heat treatment alone will not closely approximate a forging in physical quality.

By R. P. FLINTERMANN, President, Michigan Steel Castings Company, of Detroit.—The author spoke very much from the point of view of the manufacturer of the large steel casting. It might, therefore, be interesting to say a word or two from the viewpoint of the maker of the small steel casting. By that, I mean the castings, such as those we produce. Our average weight is in the vicinity of 20 pounds. The castings are largely truck castings, light machinery castings and tractor castings. They are usually on the outside of a truck, where the appearance must be good. They are machined on many of the surfaces. These castings must be of a strength such that they could not be made of malleable iron. They are of a contour such that they cannot very well be made of forgings.

Now, we make these castings in three different ways: first, by the crucible process; then, the converter process, and lately by the electric furnace. The author states that the electric furnace will produce steel of "as good a quality" as the crucible. I think crucible steel castings for a long time bore a halo to which they were not entitled, this halo having descended to the crucible steel castings by reason of their widespread use in the tool steel industry. It is our contention that steel castings of the best quality were not produced by the crucible process. First of all, the trade demanded a casting with a .25 carbon content. It was difficult to maintain this content on account of the varying absorption of carbon from the crucible itself. The greatest difficulty, however, was the fact that the manufacturer could not maintain a very high manganese content. In order to keep the manganese about .60 he had to add enough ferromanganese to successfully meet the necessary requirements, with the result that his pot was very rapidly attacked, so that instead of obtaining three heats per pot, he obtained only one heat per pot. And necessarily the steel was not as completely deoxidized as it should have been.

The converter process gave us some better results. We could maintain a higher manganese content; but here also the lack of complete deoxidization was a great drawback. We finally used the electric furnace. We have a 6-ton and a 3-ton furnace, and the results have been very satisfactory. We started running them basic. On account of the difficulty of obtaining refractories, we were obliged to change to acid practice. The experience that we have had has been such that we would not go back to the basic.

But the one great advantage we find is this: that we have a complete elimination of slag, and this is very

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essential where you have castings which must be machined on so many of their surfaces. If this slag appears anywhere on these machined surfaces, it is a fault which condemns the casting. We will shortly install another furnace which we will run basic, but we will use this in conjunction with the acid furnaces and will have a process which might be termed a reverse duplexing. The acid will be the last process. We aim to melt just a portion of our material in the basic, finishing in the acid furnaces.

I might add just a word or two about other advantages that we have found. The author referred to the difficulties of shrinkage cracks. We have less trouble with shrinkage cracks with electric steel, due primarily to two things: first, possibly a lower sulphur content, but due most of all to complete deoxidization. For some reason or other, probably absence of impurities, the steel has greater strength at higher temperatures than steel made by any other process. When the pull comes on the casting as it shortens, it stays whole instead of cracking.

One of the most useful points about electric steel is the fact that we can now make alloys successfully. We found the converter very unsatisfactory for this purpose, but now with our steel thoroughly deoxidized we get the full value of any of the alloys. We can count on a definite analysis, and as a result the heat treatment which we give that steel produces the result which we are after, and does this consistently. We were unable to do this by either the crucible or converter process. Today we are trying to develop the use of manganese steel in the pleasure car vehicle.

*The Chemical Reactions of Iron Smelting**

The Application of Actual Practice to the Chemical Theories Involved in Direct and Indirect Reduction—Solving the Problem of Premature Combustion—Praise for the Coke Producer.

By WALTHER MATHESIUS, Superintendent of Blast Furnaces, Illinois Steel Company, South Chicago Plant.

The task of the blast furnace, while performed as one continuous and interlocking process, may be divided into physical and chemical duties. Among the former the principal items are:

(A) The drying and preheating of the burden materials.
(B) The melting and superheating of the resultant iron and slag.

The chemical duties comprise chiefly—

(C) The calcination of the carbonates.
(D) The reduction of the metallic oxides of the ore burden.

The relative importance of the physical and chemical work may be best judged by comparing the amount of energy consumed by each. This can readily be calculated by establishing a heat balance.

An average taken from a number of such calculations covering modern operations shows that, of the total heat introduced into a blast furnace and generated therein, approximately 25 per cent is sufficient to take care of the above-mentioned physical duties while the chemical reactions require about 60 per cent of the total, the balance being absorbed in radiation losses and heat escaping with the gases. These figures gain particular interest when considering that it is the physical part of the blast furnace work only that is immediately accessible to observation and measurement.

From the total amount of coke which is charged into the blast furnace, a certain percentage is always carried out by the furnace gases as coke dust, and another portion is dissolved by the pig iron. At plants using similar raw materials, and under normal operations, the sum of these two items varies only within narrow limits and amounts to a small percentage of the total. It does not decidedly influence the general efficiency of the furnace operation, for which the fuel consumption is the most generally accepted criterion. The latter depends almost exclusively on the mode of gasification and utilization of the remaining major portion of the coke. The possibilities in this respect are:

1.—The carbon, having passed downward through the furnace stack, reaches the hearth and is gasified there either by:
(a) Combining with the oxygen of the blast at the tuyeres, or
(b) Combining with the oxygen of metallic oxides (direct reduction).
2.—The carbon does not reach the hearth, but is gasified above the hearth by reacting with the CO_2 of the furnace gases (premature combustion).

The reactions classed under 1 are normal operating necessities. The reaction (a) creates heat and reducing gas (CO); the reaction (b), while consuming heat, furnishes reducing gas and pig iron product. As long as their sum total and their relative proportion remain within proper limits, these reactions must be classed as desirable, while an excess of either one is superfluous and detrimental.

The reaction named under 2 produces, at a loss of heat, reducing gas only, which, if at all required in the operation of the furnace, could be more advantageously furnished by either reaction 1 (a) or 1 (b). The premature combustion of carbon must, therefore, in all cases be considered a detrimental reaction.

All three of these reactions have one thing in common. They produce carbon-monoxide, the agent by

* Abstract of paper before New York meeting of American Iron and Steel Institute, May 25.

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means of which by far the largest portion of the metallic oxides in the furnace burden is reduced to metal. This process, for which the equation $Fe_2O_3 + 3CO = 2Fe + 3CO_2$ may serve as an example, is known as "indirect reduction." Its economy is in a large measure responsible for the remarkable efficiency of the blast furnace, which to the present day has not been surpassed by any other metallurgical process.

Direct reduction, as mentioned first, takes place in every furnace and is a function of the composition of the iron; in other words, the percentage of silicon, phosphorus, manganese, etc., to be reduced and of the percentage of burden materials, the metallic contents of which are for physical or chemical reasons not accessible to the reducing action of the furnace gases. With these conditions given. this phase of direct reduction can be considered as practically constant.

The other case of direct reduction, which is due to scarcity of CO from combustion at the tuyeres, is most likely to be incurred where furnaces are burdened with ores that are easily reduced, and where such furnaces are operated at a fast rate of driving, with high-blast temperatures. Under such conditions, direct reduction will take place to a greater extent the lower the percentage of silicon is in the pig iron. Modern Mesaba practice on basic iron is a good example.

Comparing the volume of gases generated at the tuyeres per minute with the cubic contents of the furnace, and considering at the same time that the stack is not empty but filled to the top with ore, stone and coke, that therefore the only space available for the furnace gases are the voids between the solid particles, it is apparent that the time during which the volume of blast entering through the tuyeres can possibly remain in contact with the furnace burden is, at best, only a few seconds. This short interval is all that is available for each molecule of gas to undergo the various reactions which take place between the oxygen of the blast or ore and the carbon of the coke, between the resultant CO and the metallic oxides of the ore and between carbon dioxide and the carbon.

It is evident, therefore, that the extent to which the various reactions will perform within the blast furnace depends to a large measure upon the reacting speed of which they are capable. The speed of any chemical reaction decreases the closer the relative quantities of the reacting and resulting substances approach a status of equilibrium. Therefore, the various reactions cited above will, within the limited time available in the blast furnace, take place to a larger extent the farther away the relative quantities remain from the status of equilibrium.

Thus the possibility of a modern furnace being insufficiently supplied with carbon monoxide through the combustion of carbon at the tuyeres is by no means remote. It is incurred particularly where, with easily reduced ores, high blast temperatures are used, because with higher blast heat the generation of the necessary quantity of heat in the hearth requires less carbon. In modern practice this question is solved economically by permitting direct reduction to take place and at the same time off-setting the entailing heat loss by raising the blast temperature. The limit to which this direct reduction can be carried on depends on the ability to offset the resultant heat deficit in the hearth by higher blast temperature, and the necessity to keep the top temperature above the desired minimum which is essential for the timely drying and preheating of the ore charges.

The results obtained may briefly be summed up as follows: Without raising the volume of wind blown, the amount of carbon gasified in the hearth and the weight of metallic oxides reduced per unit of time is increased. The furnace operates at a higher rate of output without requiring additional coke for its hearth reactions. As the cooling and radiation losses per ton of iron are inversely proportional to the rate of production, a saving is effected in this respect, which must ultimately find its expression in a lower coke consumption. As part of the coke carbon is gasified by oxygen from the ore without the addition of nitrogen from the blast, the amount of gas per unit of burden material charged becomes less. The initial temperature of the gas leaving the hearth not being changed, this results in a lower top temperature as well as a lower temperature of the stack. The beneficial effect of this drop in stack temperature on coke consumption and on furnace practice in general will be dealt with later.

Incidentally it may be said that this line of reasoning offers a very plausible explanation for the quite frequently observed fact that in Mesaba furnaces, where high blast heats are available, the burdening of certain percentages of materials inaccessible to the reducing influence of the furnace gases, such as sinter, results in benefits as mentioned.

Direct reduction in the hearth has often been confused with direct reduction in the stack, which more correctly should be termed "premature combustion." The latter consumes coke carbon before it reaches the hearth by attacking it and dissolving it in carbon dioxide in the upper regions of the furnace according to the equation $CO_2 + C = 2CO$.

Its influence on the furnace efficiency, both thermal and with reference to carbon consumption, is the same as that of excess direct reduction in the hearth. Since its reacting speed grows rapidly with rising temperatures, it is evident that premature combustion must take place in the furnace stack at an increasing rate the higher the temperature of the zone in which the carbon dioxide and the coke come into mutual contact and the longer they remain in contact with each other at temperatures above 900 deg. C.: that is, generally speaking, the higher the average stack temperature of the furnace happens to be. The apparently logical means of counteracting this condition is "faster driving." In

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many cases this can only be practiced after a change in the quality of coke has been brought about.

I refer especially to the combustiblity of the coke, the importance of which was first emphasized and termed by Mr. H. A. Brassert in his paper on "Modern American Blast Furnace Practice," read before this Institute in May, 1914. This quality, above all, determines the pace at which a furnace can be operated. Unfortunately, a change of coke structure which tends to improve its combustibility will in many instances simultaneously increase its vulnerability to the solving action of gases.

Recently, modern American coke-oven practice has made enormous strides towards approaching the apparently paradoxical ideal of a coke which with the highest rate of combustibility would combine immunity from solution in furnace gases. This is accomplished by producing coke with an open-cell structure in which the cell walls themselves are amply strong and well protected by a graphitic coating. The results accomplished in this respect are in a large measure responsible for the remarkable improvement of coke practice which has been obtained at a good number of American blast-furnace plants during recent years.

Among the ways and means which counteract premature combustion and are practiced aside from faster driving, one is now so universally used that its value is often overlooked. I refer to the use of raw limestone as flux. The explanation lies obviously in the fact that the endothermic calcination of the limestone, which takes place above 900 deg. C., is one of the most effective means to quickly bring about a cooling of the furnace gases below the zone of temperature where premature combustion can take place; it appears that thereby, and by simultaneously preventing premature fusion of the ores, which would place the latter beyond the reach of indirect reduction, more coke is preserved and made available for the generation of heat at the tuyeres.

Another most effective means of preventing premature combustion is the application of high blast temperatures. By thus accelerating combustion at the tuyeres, providing for the hearth's heat requirements with less fuel and a consequently lower volume of gases, concentrating the zone of highest temperature and increasing the ratio of descending materials to rising gases, a decided lowering of the average stack temperature with correspondingly better fuel economy, can be and has been accomplished. For instance, the blast furnaces at South Works, Illinois Steel Company, being operated according to these principles, have for a number of years, in spite of a severe handicap in the form of irregular coke supply, not for a single month exceeded a coke consumption of 1,900 pounds per ton of iron for twenty-one consecutive months. During the year 1916, these same furnaces, with an average age of 331,771 tons per lining, produced 2,066,256 tons of iron on an average coke consumption of 1,854 pounds per ton.

From the analysis of the various reactions, it is evident that direct reduction and premature combustion in reference to origin, performance and prevention are two distinctly and entirely different processes. The only common tie between them is their endothermic character and the fact that they both consume carbon. The sum-total of their carbon consumption represents what is usually called the amount of carbon gasified above the tuyeres. As this carbon is consumed partly by economical and partly by wasteful reactions in ever-varying proportions, it is evident that the relation of this total "carbon gasified above the tuyeres" to the fuel consumption of a furnace cannot possibly have a direct bearing on the economy of the furnace operation.

These relations have until quite recently remained obscure, because it was considered impossible to separately calculate direct reduction and premature combustion, while their combined total could be obtained with comparative ease by either subtracting the weight of the carbon gasified at the tuyeres from the total carbon gasified in the furnace, or by directly using the following mathematically developed and therefore universally applicable formula:

$$C_x = \tfrac{3}{4}O_e - \frac{7m}{11+7m}(C - C_{Fe}) + \frac{11}{11+7m}C_{ez}*$$

C_x means the amount of carbon gasified above the tuyeres,
O_e the oxygen contained in the metallic oxide of the burden,
m the ratio by weight of CO_2 to CO in the top gases,
C the total weight of carbon charged,
C_{Fe} the weight of carbon absorbed by the pig iron, and
C_{ez} the carbon contained in the CO_2 of burden and flux.

To cite in detail the method of dissecting this "C_x" into its constituents, direct reduction and premature combustion, is beyond the scope of this paper. Suffice it to say that it is done by establishing separate balance sheets for the hearth and stack with reference to heat as well as materials. and therefrom determining the theoretical top temperature for varying percentages of the two constituent reactions involved.† The light which this method of calculation is able to throw upon the economics of furnace operations would seem to justify the belief that it is the solution for the most complicated of blast-furnace puzzles.

From the standpoint of an operating man, I have attempted to give a brief outline of a subject about which volumes have been written by men of science without ever covering the field. To them belongs the task of further theoretical exploration. We blast-furnace operators must be ready to apply and prove in practice.

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* Professor W. Mathesius, "Investigations Concerning the Blast Furnace Process" ("Untersuchungen ueber die Vorgaenge im Hochofen"), Stahl und Eisen, 1913, page 1467.

† Professor W. Mathesius, "Die physikalischen und chemischen Grundlagen des Eisenhuettenwesen." Spamer, publisher, Leipzig, Germany, 1916.

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Alumina as a Component of Furnace Slag

Characteristics Due to Alumina; Relations It Bears to Other Slag Components and the Practical Interpretation of Slag Peculiarities Which Are Attributed to Alumina.

By WALLACE G. IMHOFF.

High percentages of alumina have been considered extremely detrimental in blast furnace slags. This caution seems to be due to the lack of positive knowledge of just what effect alumina has on slags rather than to the facts which have been attributed to it. The following observations have been made very carefully and it is hoped that other furnacemen can bear out the findings.

In the past large percentages of alumina have been considered very harmful; in fact when the furnace has gone off and the cinder becomes extremely heavy, thick, and infusible, the difficulty has been attributed to alumina. Very light, foamy slags which run out over the cinder runner have also been classed as high in alumina and this peculiar performance attributed to it.

The sources of alumina are the coke, ore, and stone of the charge. The average alumina from about fifty different coke analyses falls between 2.50 and 3.50 per cent; the average alumina found in the same number of ores averages between 1.75 and 3.00 per cent, and the average alumina in a number of limestones shows well under 2.00 per cent. In most of the above cases for all three the alumina falls well under the high limit. These figures show that the actual amount of alumina going into the furnace changes very little, hence radical changes in percentages of alumina must be attributed to some other cause.

A very close study of this component in slags has revealed some very interesting facts, some perhaps of which are new. The apparently wide variations in amount of alumina in slags are caused by change in slag volume as illustrated by the following analyses of cinder from basic iron and cinder from foundry iron. Twelve ladles of cinder per day were made while making foundry iron. This same furnace made fifteen ladles of cinder per day when put on basic iron and the alumina going into the furnace was practically the same in each case. The actual changes in percentage of alumina are shown below:

Foundry Iron.

Iron.

Silicon	2.15	2.13	2.24	1.98	2.29
Sulphur	.039	.042	.038	.040	.033

Cinder.

Silica, 31.48; alumina, 18.08; lime, 38.70; magnesia, 8.82; iron, .49; sulphur, 2.43.

Basic Iron.

Iron.

Silicon	.61	.90	.87	1.06	1.02
Sulphur	.039	.033	.031	.027	.028

Cinder.

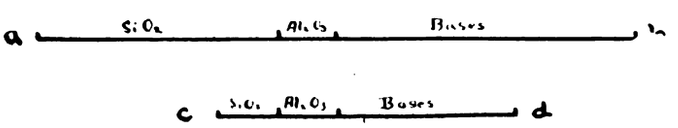
Silica, 36.08; alumina, 10.52; lime, 43.10; magnesia, 7.87; iron, .63; sulphur, 1.56.

A comparison of the above shows a percentage difference of alumina of about 8 per cent. The important fact is that the amount of alumina did not change considerably but that the actual amounts of lime and silica did, thus automatically reducing the percentage of alumina from 18 to 10.

As a general thing all slags under 13 per cent in alumina are slags from basic iron while foundry iron slags generally run 13 per cent or above. This dividing line is not positive for like other things in practice it is not unusual to have them overlap. Alumina in the furnace is considered fairly constant unless it is positively known that with a change of burden a high alumina ore is put on. Therefore the radical changes in percentages of alumina are due to other sources and one explanation is perhaps due to the following cause:

For the sake of illustration the alumina will be considered constant and the diagrams will be exaggerated

Figure I.



to bring out the point under discussion. In Figure 1 the line **a-b** represents slag volume and the total volume is represented in length by 10 units. The alumina in this slag is shown as one unit of 1/10 of the total slag volume and therefore as 10 per cent of the slag. Thus in the first slag the alumina is one unit out of ten and the actual percentage is 10 per cent of the whole.

Now the furnace is put on foundry iron and the silica is reduced and goes into the iron. The bases are very much lower, and the actual quantity of alumina is about the same. Hence the slag volume is reduced and as stated above for the sake of illustration, the total volume represented by the length of the line **c-d** is now only five units. But the unit of alumina is the same as before and it is now not one unit in ten units or 10 per cent, but one unit in five units or 20 per cent. Thus the percentage change of alumina is only theoretical and not actual. The unit amount which

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is 10 per cent of ten, is 20 per cent of five, and this is precisely what is shown by slag analyses though of course, not so extremely exaggerated.

This same illustration may be a little clearer by referring to Figure 2, where the slag volume is represented by the height of boxes.

According to Hempel, alumina melts at 1,880 deg. C. and to Kanolt at 2,050 deg. C. Therefore it is seen that alumina should not give much trouble in slags. This fact is verified by closely watching high alumina slags. Another fact of extreme importance is that high alumina slags are generally low silica slags and still no difficulty is encountered. On running high alumina slags are very fluid and seem to be an ideal slag.

The question now arises: what is the explanation? The answer is that the part alumina plays in slags has been confused with the other components, or perhaps the other way round, the part of the other component has been confused with that of alumina. To further explain how this has been done a few slags will be considered, but before entering into the discussion we will also look into some of the properties of the other components of slags.

The following data has been taken from Clark's Data of Geochemistry of the United States Geological Survey. Pages 293-294.

Melting points.	Deg. C.
Mg SiO_3 (artificial)	1557
Ca SiO_3 (artificial)	1540
Quartz—silica	1625
Magnetite	1190-1225
Hematite	1300-1400
Fluorite	1387
Silica (Roberts Austin)	1775
Silica (Hempel)	1685
Alumina melts (Hempel)	1880
Magnesia melts (Hempel)	2250
Lime melts (Hempel)	1900
Al_2O_3 melts (Kanolt)	2050
MgO melts (Kanolt)	2800
CaO melts (Kanolt)	2570
Cr_2O_3 melts	1990

Other melting points of interest are those of G. Stein, made with a Wanner pyrometer:

Quartz (silica) viscous semi-fluid	1600
Quartz (silica) liquid	1750
$CaSiO_3$	1512
Mg. SiO_3	1565
Fe SiO_3	1500
Mn. SiO_3	1470-1500
Mg. SiO_4, below	1900

In the silicates the melting point falls as the iron increases.

With the above data in front of us we are now ready to go into further detail in the discussion of alumina in blast furnace slags. It is almost always found that when the alumina is very high, the silica and the bases are low. The metallurgy of high alumina slags show that alumina distinctly plays the part of a base forming aluminum silicate and that the lime combines with the sulphur which explains the low sulphur iron with a small amount of lime on the charge.

In general terms then high alumina slags give the following metallurgical results in the iron and slag:

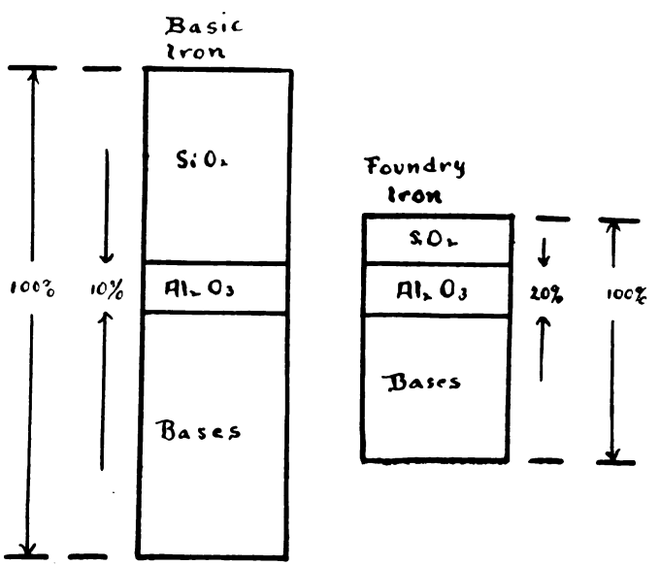
Iron	
High silicon.	Low sulphur
Slag	
Low silica High alumina Low bases	Aluminum-silicates Lime-sulphide High sulphur slags

This discussion is based on a normal working furnace making foundry iron with a low fusion zone and high hearth temperature. Entirely different results would be obtained with exactly the same material under different furnace conditions, therefore one of the prime requisites for determining slag is to understand precisely the furnace conditions under which it was made.

Close study of hundreds of slags of all types has revealed the fact that high percentages of alumina are not harmful, that at certain times alumina distinctly plays the part of a base in combining with the silica, and that the heavy, viscous slags thought to be caused

Figure II

Diagrams of Slag Volume



by high alumina are in reality due to low silica, high lime and magnesia.

Alumina colors slags blue. This varies according to the proportion of silica and bases in the slag. Slags high in silica show a glass edge and a blue center, slags low in silica are a dry blue and grainy, slags high in silica bases show a very heavy stony blue, while slags extremely high in silica and bases are cream white and the blue color due to alumina has been completely overshadowed by the white of the lime and magnesia. When the lime is low and the silica extremely high the blue of the alumina is again overshadowed by the green of the iron or if the slag is cold by the brown of the manganese. These are green and brown glass slags. Iron will overshadow all other

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clors and an extremely cold slag will be ink black due to the coloring of iron oxide.

Again refer to the light foamy slags which have been called high alumina slags. A second thought will bring out the fact that alumina is not a gas and hence cannot make the cinder light and foamy. The real explanation is that precisely the same conditions are present as in the high alumina slag discussed above save that the furnace now is working on a high fusion zone instead of a low fusion zone and the sulphur is carried as free sulphur in solution in the slag. On reaching the air the conditions of temperature and pressure are changed to atmospheric temperature and pressure hence the free sulphur tends to escape from the slag as gas and causes the light foamy cinder which often even rolls over the sides of the cinder runner.

The high fusion zone has caused the lime and alumina to combine with the silica and the sulphur is carried out as free sulphur in solution. These slags are suffocating from the sulphur fumes and they may be seen rising from the slag as a heavy blue smoke. This slag may analyze precisely the same as the former

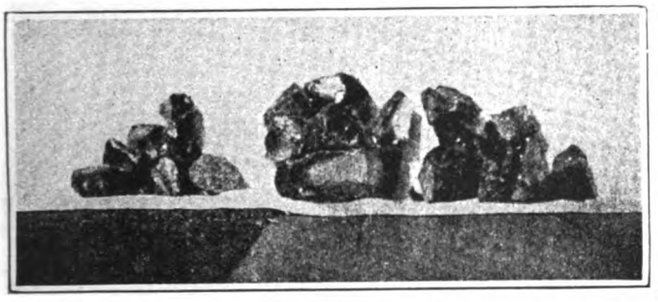

Fig. 3.—This illustration shows an excess of silica, the glass edge and blue aluminum center.

slag save for one thing, the amount of sulphur. The former slag will show from 2.50 to 2.75 per cent sulphur while the latter will show about 1 per cent less, say about 1.40 to 1.60 per cent.

High alumina slags are very fluid when hot but like all cold slags thicken with a drop of temperature. From the above data it is seen why high alumina is not detrimental to slags but rather beneficial if understood. The shortage of bases, lime and magnesia, lowers the melting point and hence if the fusion zone is low and the hearth kept hot a minimum of lime may be used. This fact is worthy of note for it can cut down the cost considerably by using much less stone and coke on the charge. Besides the lowered cost of stone and coke it also tends to make the furnace drive more smoothly and regularly, and increase the tonnage. A word of caution should be mentioned at this time for a rise of fusion zone due to increase of wind or low stone heat will immediately raise the sulphur in the iron due to the shortage of lime. Two features necessary for success with this character of slag are high hearth temperature and low fusion zone.

One particular feature of interest here and which is probably brought out for the first time is the explanation of poor gas with extremely high alumina, low lime slags. The writer remembers a specific case of this kind where the gas was so bad that the boilers found it extremely difficult to keep up the normal steam.

The cause of the trouble is deep seated and requires

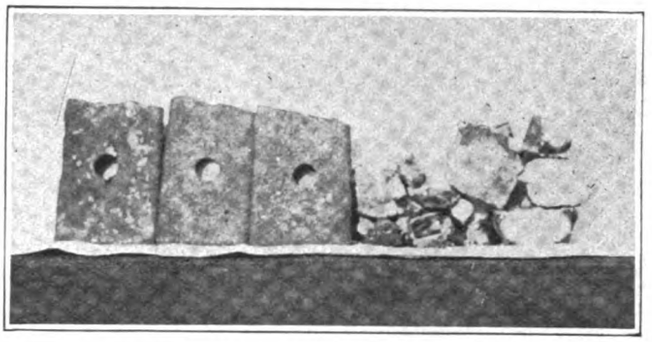

Fig. 4.—This illustration shows solid blue aluminum slags with a much lower proportion of silica than illustration 3. Small glass edges.

a close study before it can be fully appreciated. The lime combining with sulphur tends to promote the freeing of carbon which supplies carbon for the gas. With slags very high in lime on a high hearth temperature giving a maximum combination of lime and sulphur the iron is extremely dry and mushy due to the removal of carbon in the form of graphite. The gas under these conditions carries a maximum of carbon, hence is the yellowest and hottest gas, therefore the reason for good steam. On the other hand with high alumina, low lime slags the alumina and lime are almost all combined with the silica, hence free sulphur, therefore most of the carbon goes into the iron as combined carbon, hence a minimum of carbon goes into the gas, therefore a low heating value, blue burning gas, and low steam.

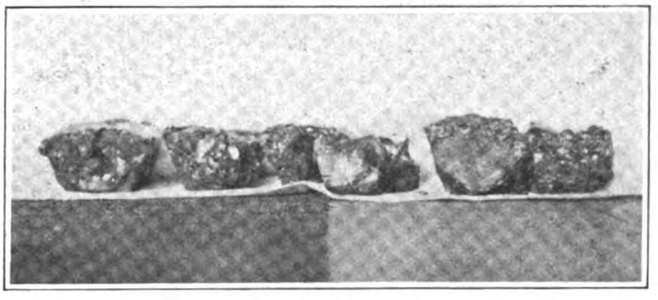

Fig. 5.—Alumina overshadowed by black, due to iron oxide.

A discussion of heating values of furnace gases will appear later, the above serving merely to explain the gas conditions on high alumina slags.

Again turning to extremely thick, heavy, black, viscous slags which have been said to be caused by high alumina. These slags will generally be found to carry from 12 to 14 per cent of alumina. Referring

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to the above table again it is seen that lime melts at 2570 deg. C. and magnesia at 2800 deg. C. hence a slag carrying too much lime and magnesia would tend to have an extremely high melting point. This is precisely the cause of these heavy viscous slags, too much lime and magnesia. As much an excess as 1500 pounds of stone to the round have been on the charge or a total for 24 hours of 50 to 60 rounds or 60,000 pounds too much stone. Under these conditions the furnace hangs and slips violently, production is extremely low, and operation carried on with extreme difficulty. Too much lime will slow down the driving of the furnace, increase costs, and lower tonnage. Conditions of this kind are not caused by high alumina as many furnacemen have thought, but too much lime and magnesia.

Enter Roller Bearings for Steel Mill Cars

The Steel Industry Takes a Hand in the Rolling Stock Efficiency Game—Interesting Tests by Steel Companies on Train Resistance, Made by a Dynamometer Testing Device—Results of Findings.

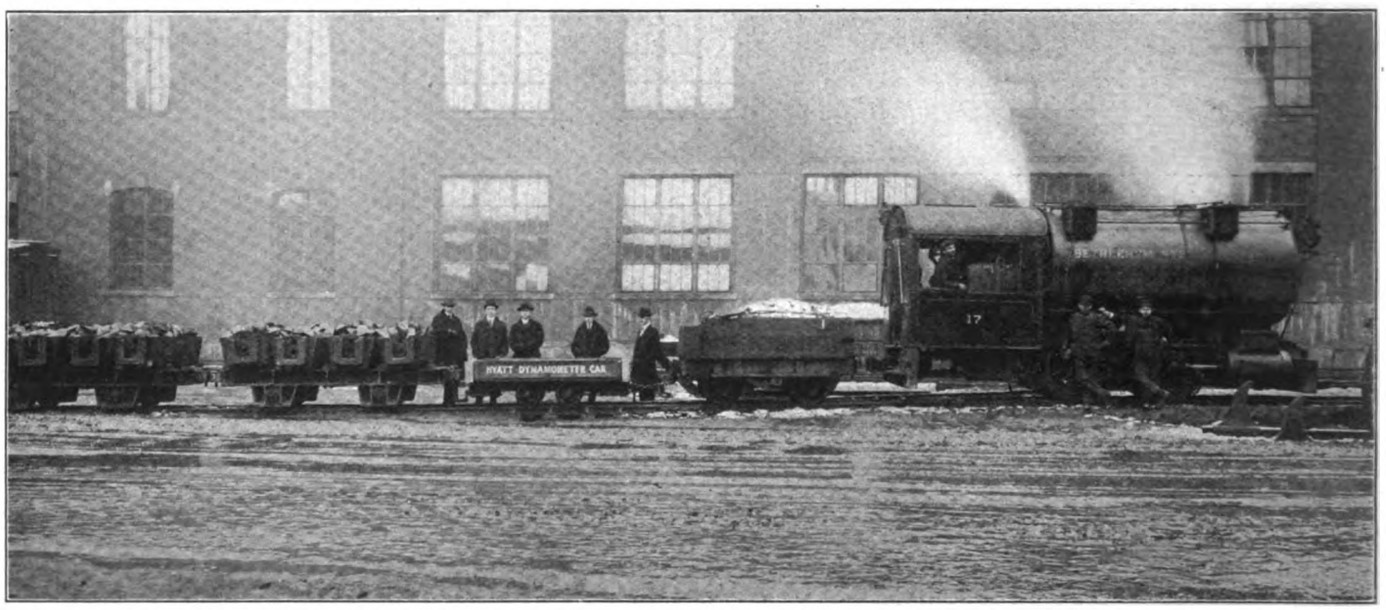
By P. B. LIEBERMANN.

The first engineers to seriously consider train resistance and the possibilities of its reduction were railroad men. The railroad dynamometer car has long been an established fact and a piece of apparatus the reliability of which has been clearly recognized.

In every steel plant there are miniature railroad systems. But to my knowledge very little has ever been done to obtain accurate figures by scientific means of track resistance, journal friction and grade resistance.

The reason is plain. The business of a steel mill engineer is to get out steel. The haulage system is merely a means to an end. Of course, every steel mill engineer knows that there is such a thing as journal friction and track resistance. But how much these items amount to is what counts.

When it was decided to start a thorough investigation into the merits of roller bearings in comparison with ordinary plain bearing for steel mill cars, it was clearly seen that it would be very desirable to use a special testing device in order to get the best results. Since the railroads have used the dynamometer successfully, it was decided to use a dyamometer car that could be used in testing steel mill cars. The car that I designed is absolutely self-contained and is intended



Hyatt dynamometer car at the Bethlehem Steel Company—It is connected to a train of Hyatt roller bearing cars.

to be placed in front of a train of cars that are to be tested and behind the locomotive. This dynamometer car contains the following instruments:

1.—A hydrosatic pressure diaphragm, connected by means of a heavy brass tube to a pressure gage and recording pen. The whole system is filled with oil and is permanently sealed after great care has been taken to expel every particle of air.

2.—An electric speedometer. This consists of a

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good-sized magneto, chain-driven from one of the axles, and a recording voltmeter, calibrated to register directly miles per hour.

3.—A time-marker clock, which makes a mark on the record paper once every 5 seconds and a double mark every minute.

4.—The apparatus for driving the record paper. The paper travels from the paper roll over a table and past the recording pens to a drum which is chain-driven from one of the axles.

The three readings: Draw bar pull, speed, and time, are recorded simultaneously and are so arranged as to be always in synchronism.

The profile of the road over which a test is run is added by hand on a wide margin provided for that purpose on the record paper, in its proper relation to the graphical records.

As the paper is driven from the axle the paper-travel is a function of the distance covered by the train. For every mile the train runs, the paper travels 33 inches. Heavy divisions on the record paper represent 0.1 mile; fine divisions represent 0.01 mile. Under the conditions the records cannot be integrated for mean values, except for periods during which the speed is fairly constant.

TEST AT CARNEGIE MILLS.

Report of test on steel mill cars made at the Carnegie Steel Company's plant, Youngstown, Ohio,—April 15, 1917.

This test was made to obtain some general information on the train resistance of steel mill cars equipped with plain bearings in comparison with the train resistance of cars equipped with Hyatt Roller Bearings.

A comparative test was run on Ingot Cars and another test on Charging Cars.

Description of Cars.

The following types of ingot cars were tested:

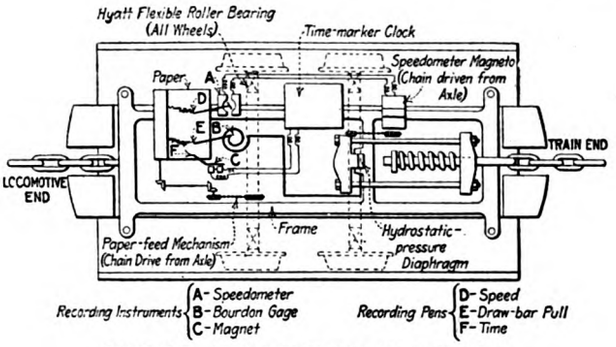
Item No.	Type of bearing	Location of bearing	Diam. of axle in bearing	Length of bearing	Track gauge	Diam. of wheel	Wheel base
1	Plain Bronze	Outside Box	4⅜"	7 5/32"	36"	20"	36½"
2	Hyatt	Outside Box	4"	6"	36"	20"	36½"

The truck frames of these ingot cars are made of cast steel. The plain bearing cars do not have springs between the bearings and the frame, while the Hyatt equipped cars have springs interposed between the bearing box and the truck frame.

The following types of charging cars were tested:

Item No.	Type of bearing	Location of bearing	Diam. of axle in bearing	Length of bearing	Track gauge	Diam. of wheel	Wheel base
1	Plain Bronze	Outside Box	3¼"	6¼"	36"	20"	42"
2	Hyatt	Outside Box	4"	6"	36"	20"	54"

The truck frames of these charging cars are made



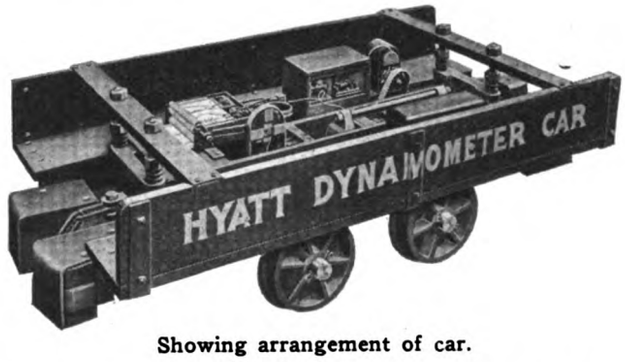
OUTLINE AND DIAGRAM OF THE CAR

of structural steel. The plain bearing cars are not provided with springs, while the Hyatt equipped cars are equipped with springs between the bearing box and the truck frame.

The distance from the center line of the draw bar to the top of the rails measured 20 inches in each case. All of the different cars had been in service for considerable time and neither type of car received any special attention before this test was made, in fact, all of the cars were selected at random and were in a condition corresponding to every day service.

Testing Device.

The Hyatt Dynamometer car was used. This car



Showing arrangement of car.

has been fully described in the June 1916 Bulletin of the American Institute of Mining Engineers. It is equipped with record instruments and is entirely automatic in its operations. It is inserted between the locomotive and the train and marks on the record paper the draw bar pull in pounds and speed in miles per hour. Full particulars regarding the train resistance

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can be read off the record charts for any piece of track.

Testing Arrangement.

Ingot Cars:—Two different trains of 8 cars each were used, one train being made up of cars with plain bearings, the other train consisting of cars with Hyatt bearings. Each car was loaded with 2 molds containing 2 ingots. Each train was run over the scale and the following weights were recorded:

Plain bearing cars:

8 Ingot cars + 8 stools + 16 molds + 16 ingots = 297,140 pounds = 148.6 tons.

Hyatt equipped cars:

8 Ingot cars + 8 stools + 16 molds + 16 ingots= 299,120 pounds = 149.6 tons.

Charging Cars:—Two different trains of 15 cars each were used, one train being made up of cars with plain bearings, the other train consisting of cars with Hyatt bearings. Each car was loaded with 3 molds

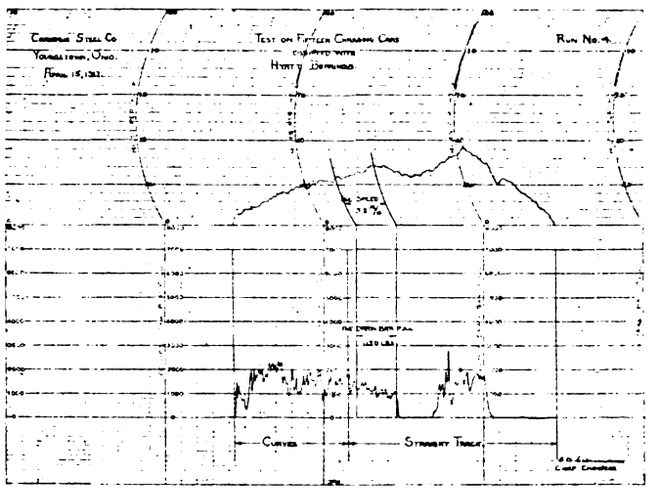

Fig. 1.

containing all the necessary materials for charging of the Open Hearth Furnace.

Plain bearing cars:

The gross weight of the 15 loaded cars = 265,100 pounds = 132.6 tons.

Hyatt equipped cars:

The gross weight of the 15 loaded cars = 292,000 pounds = 146 tons.

One train at a time was tested by pulling it by means of a steam locomotive over the track with the Dynamometer Car inserted between the locomotive and the train.

The tack was level in each case.

The rails of the track weighed 85 pounds per yard. They were dry and in good condition when these tests were made.

The tracks used for the test were selected by the Carnegie Steel Company.

The charts do not show a sufficiently long record during which the speed was uniform enough to be used for the calculation of train resistance. Therefore a suitable piece of record was selected during which the acceleration was uniform and correction was made for the amount of draw bar pull, expended for acceleration.

Result of Test.

Instantaneous values of the draw bar pull and speed anywhere along the track can be read right off the charts, copies of which are attached hereto.

For average values of draw bar pull, the graphical record was measured with the Plainmeter.

The following table contains the average values of draw bar pull and the speed of the different tests:

Test No.	Type of cars	Type of bearing	No. of cars	Wt. of train, tons	Starting pull, lbs.	Average running pull, lbs.	Average speed, (hr.)
1	Ingot	Plain	8	148.6	12,000	5,200	4.875
2	Ingot	Hyatt	8	149.6	5,400	1,500	4.5
3	Charging	Plain	15	132.6	4,500	2,100	4.125
4	Charging	Hyatt	15	146	1,650	1,150	3.2

These figures have to be corrected for acceleration, that is 91.2 pounds per ton have to be subtracted for each one mile per hour change in speed per second.

The corrected draw bar pull is given in the following table together with the tractive effort expressed in pounds per ton of train weight.

	Average running pull, lbs.	Acceleration force; lbs.	Corrected D.B.P., lbs.	Expressed in lbs./tons.	Saving
1	5,200	826	4,374	29.5	75.5%
2	1,500	596	904	6.03	
3	2,100	347	1,753	13.25	55.3%
4	1,150	285	865	5.92	

The test figures clearly demonstrate that in steel mill service a correspondingly larger number of cars can be pulled by the same locomotive if Hyatt Roller Bearings are substituted for plain bearings, and at the same time the speed can easily be doubled which means an all around speeding up of production without additional outlay for locomotives. The saving of power is particularly noticeable when storage battery locomotives are used.

When running up grade, as for instance to the charging floor of the Open Hearth Furnace, a correspondingly larger number of cars can also be pulled, depending on the percentage of grade and the draw bar pull of the locomotive.

The several tests agree very well with the tests made at the Bethlehem Steel Company. The results can be considered as applying equally well to other cars and buggies used around a steel plant such as ladle cars, slag cars, etc.

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No particular attention has been paid to the conducting of starting tests and it was not even possible to obtain the same amount of acceleration for each one of the four tests. It is obvious that when setting a train in motion the draw bar pull will be seriously effected by the way the locomotive throttle is handled. Tests made by the Dynamometer Car, particularly in coal mines have demonstrated that the draw bar pull for starting Hyatt equipped cars is about the same as the draw bar pull which they require for running, while in the case of the plain bearing cars, the draw bar pull for starting is many times as great as the daw bar pull for running.

TEST AT BETHLEHEM MILLS.

Report of test on charging cars made at the Bethlehem Steel Company's Plant, South Bethlehem, Pa.—March 3, 1917.

This test was made to obtain some general information on the train resistance of charging cars equipped with plain bearings in comparison with the train resistance of charging cars equipped with Hyatt Roller Bearings.

Description of Cars.

The following types of cars were tested:

Item No.	Type of bearing	Location of bearing	Diam. of axle in bearing	Length of bearing	Track gauge	Diam. of wheel	Wheel base
1	Plain Bronze	Outside Box	4″	6″	36″	24″	63″
2	Hyatt	Outside Box	3¼″	7″	36″	16″	60″

The frames of the plain bearing cars were made of structural steel while the frames of the Hyatt equipped cars were made of cast steel.

The distance from the centre line of the draw bar pull to the top of the rails measured 21-in. in each case. The plain bearing cars had been in service for a number of years and the Hyatt cars had been in service for about two years. Neither type of car received any special attention before this test was made, in fact, all the cars were selected at random and were in a condition corresponding to every day service.

Testing Device.

The Hyatt Dynamometer Car was used. This car has been fully described in the June 1916 Bulletin of the American Institute of Mining Engineers. It is equipped with recording instruments and is entirely automatic in its operations. It is inserted between the locomotive and the train and marks on the record paper the draw bar pull in pounds and speed in miles per hour. Opposite this record the profile of the road is drawn in by hand so that at a glance, full particulars regarding the train resistance can be read off the chart for any grade or piece of track.

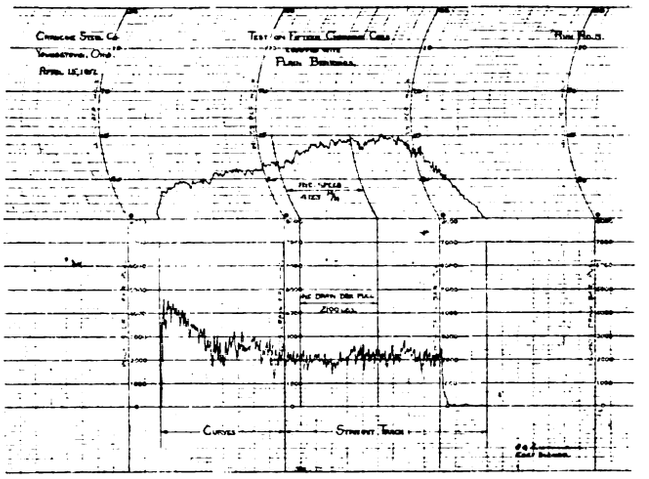

Fig. 2.

Testing Arrangement.

Two different trains of 6 cars each were used, one train being made up of cars with Hyatt bearings. other train consisting of cars with Hyatt bearings. The cars were loaded with pig iron and were in a condition corresponding to the service under which they are taken to the Open Hearth Furnace. The cars of each train were run over the scale and the following weights were recorded:

6 PLAIN BEARING CARS			6 HYATT BEARING CARS		
Gross Lbs.	Net Wt. Lbs.	Tare Wt. Lbs.	Gross Wt. Lbs.	Net Wt. Lbs.	Tare Wt. Lbs.
38,100	21,900	16,200	28,400	16,100	12,300
40,500	25,100	15,400	26,900	14,600	12,300
40,700	24,700	16,000	27,300	15,000	12,300
			27,900	15,600	12,300
			28,400	17,300	11,100
			27,900	15,600	12,300
119,300	71,700	47,600	166,800	94,200	72,600

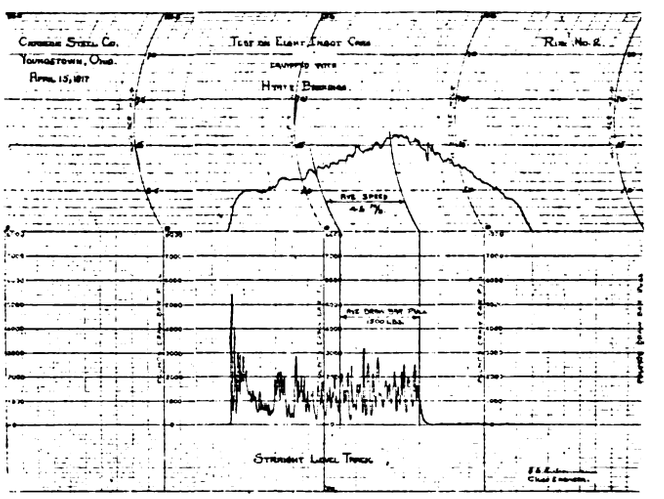

Fig. 3.

In the case of the plain bearing cars, the weight of two cars was taken at the same time, while in the case of the Hyatt equipped cars, one car at a time was

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weighed. One train at a time was tested by pulling it by means of a steam locomotive over the track whose profile is shown on the charts and with the Dynamometer Car inserted between the locomotive and the train.

The test of each type of train was repeated four times.

The rails of the track weighed 80 pounds per yard, and were wet and in good condition when these tests were made.

The piece of track used for the test was selected by the Bethlehem Steel Company. This particular pieces of track contained a pronounced grade. All tests were made by pulling the trains up on this grade. The profile and other particulars of the track are contained on the Bethlehem Steel Company's print No. 109,887-1/8-92-7.

The profile of the track was placed on the charts by hand according to the survey of the steel company.

In selecting a suitable section of the profile the length of the train has to be considered and although the run was exceedingly short it was possible to select

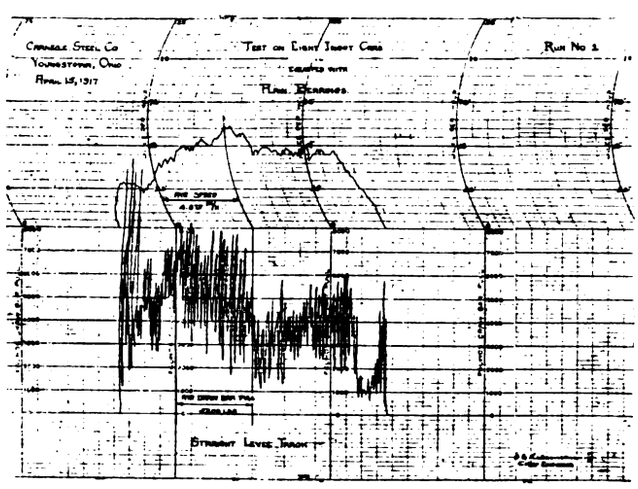

Fig. 4.

for the calculation of train resistance, any long enough stretch with fairly uniform grade, which in this particular case was .9 per cent.

Result of Test.

Instantaneous values of the draw bar pull and speed anywhere along the track can be read right off the charts, copies of which are attached hereto.

For the average values of draw bar pull and speed, the graphical record on the before mentioned grade were measured with the Planimeter.

Referring to the charts:—Tests No. 2, No. 3, No. 7 and No. 8 respectively were used for figuring train resistance for the following reasons:

During these tests the speed has been fairly constant which is important in order to eliminate acceleration and deceleration. The other tests have not been utilized for the following reasons:

Test No. 1.—The speed after reaching a maximum drops down rapidly.

Test No. 4.—Only half of the results had been recorded because the recording paper got accidently stuck in the paper feeding mechanism.

Test No. 5.—The speed was very much lower than in any one of the other tests.

Test No. 6.—The speed was very much higher than in any of the other tests.

The following table contains the average values of draw bar pull and speed based on tests No. 2, No. 3, No. 7 and No. 8.

Type of Bearing	Average Grade	Test No.	Average Draw Bar Pull	Average Speed
Plain	.9%	7	3,000 lbs.	3¼ mi. per hr.
		8	3,000 lbs.	3½ mi. per hr.
Hyatt	.9%	2	2,100 lbs.	3.1 mi. per hr.
		3	2,100 lbs.	3.2 mi. per hr.

These figures have to be corrected for gravity, that is 20 pound per ton per 1 per cent of grade has to be subtracted from the above draw bar pull. For the train with plain bearing cars weighing 60 tons, the correction amounts to 1080 pounds, while for the train with Hyatt bearings cars weighing 83.5 tons, the correction amounts to 1500 pounds.

In other words, the corrected tractive effort amounts to

3000 lbs. — 1080 lbs. = 1920 lbs.

for the plain bearing cars, and

2100 lbs. — 1500 lbs. = 600 lbs.

for the Hyatt equipped cars.

Expressed in pounds per ton this means for the plain bearing cars 32 pounds per ton, and for the Hyatt equipped cars 7.2 pounds per ton. The saving in favor of the Hyatt equipped cars therefore amounts to 77½ per cent.

Inasmuch as the majority of tracks around a steel mill are on the level ground, it means that a correspondingly larger number of cars can be pulled by the same locomotive if Hyatt Roller Bearings are substituted for plain bearings, and at the same time the speed can easily be doubled which means an all around speeding up of production without additional outlay for locomotives. The saving of power is particularly noticeable when storage battery locomotives are used.

When running up grade, as for instance to the charging floor of the Open Hearth Furnaces, a correspondingly larger number of cars can also be pulled, depending on the percentage of grade and the draw bar pull of the locomotive.

While the piece of track on which the test was made has been comparatively short, yet the record charts show that the several tests agree very well with each other and the difference between the two types of cars is so pronounced that the results can be considered as applying equally well to other cars and buggies used around a steel plant, such as ingot cars, ladle cars, slag cars, etc.

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The Elements of Roll Pass Design

How Modifications in Existing Conditions Affect Supposedly Positive Rules—Fixing the Limitations on Possible Reduction Per Pass—Action of Materials Under Compression.

By W. TRINKS.

Most of the publications which have dealt with roll pass design are based solely upon experience. Likewise, almost all practical design of roll passes is directly based upon experience. If an existing design which has been successful elsewhere can be copied directly, and if all other features, such as temperature of steel, hardness of steel, diameter of roll, length of roll, peripheral speed and rate of cooling can be maintained duplicates of those existing in the case of the original design, then and in that case no skill is needed on the part of the roll designer.

If however, changes must be made from the original conditions, the skill and the experience of the roll designer come into action. Now, science is coördinated knowledge, and the present contribution aims to assist in placing roll pass design on a scientific basis by so coördinating and correlating knowledge and experience that less guessing need be done than heretofore. Experienced designers and roll turners will probably smile at the efforts of the author, but for such men the present paper is not intended. On the contrary, the intention is to help those who still are at or near the bottom of the ladder so that they may reach the top more quickly and with fewer mistakes.

In roll pass design, the following questions must be considered:

1.—What is the greatest permissible reduction?

2.—What is the resulting lateral spreading?

3.—How much side work must be done?

GREATEST PERMISSIBLE REDUCTION.

Evidently, it is desirable to reduce the stock as much as feasible in one pass, because each additional pass means more time, more labor, more complication. The question then is: What does "as much as feasible" mean? Since most problems become clearest by carrying limiting features to extremes, let us try to reduce a 6-in. x 6-in. billet to a 1-in. x 1-in. billet in two passes. The rolling would have to be done somewhat as indicated in Fig. 1, in which the billet is first reduced in one direction to ¾ inch, allowing the material to spread laterally to, say 7-in., and in which the resulting flat is then reduced from about 7-in. x ¾-in. to 1-in. x 1-in. If such reductions were attempted, several troubles would arise. First, the roll diameter would have to be excessive. It would not do to rough or rag the rolls very much because the resulting ripples would remain on the bar and would not be smoothed out as they would be in the finishing passes in the case of many passes with a comparatively small reduction in each of them. To make the rolls bite without deep-cut roughing, the angle of contact must not exceed 22 degrees. Hence roll diameter equals $(6\tfrac{3}{4}) / (1-\cos 22^\circ) = \frac{5.25}{.0728} = 72$ inches. This is a larger roll than has ever been made as far as the author knows. A roll of approximately the same size would be needed to reduce the 7-in. x ¾-in. to 1-in. x 1-in. The large roll would have to turn very slowly to keep the rolling speed within limits and would require more gearing than rolls now do. The housing would be of enormous size for rolling such a small bar.

All of these inconveniences might be accepted, but

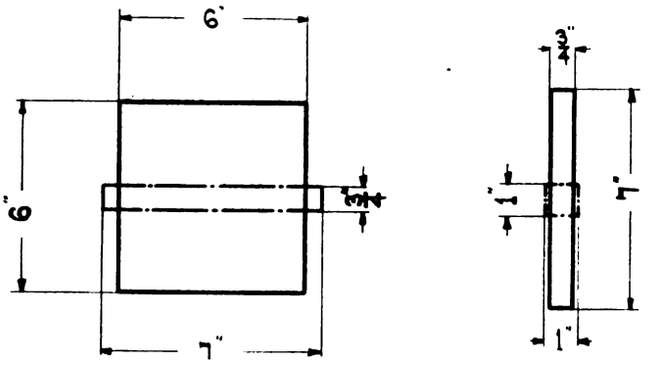

Fig. 1.—Diagram illustrating impracticability of extremely heavy reductions.

the latteral spreading of the steel in the pass makes a reduction of such magnitude absolutely impossible. In reducing from 6-in x 6-in . to 7-in. x ¾-in., lateral spreading cannot be prevented by the collars, because the latter, as will easily be seen from Fig. 2, must be less than ⅜-in. high. Spreading occurs all along the section lined portion before the stock reaches the place where the collars come close together, with the result that the material squeezes out on the side and forms a fin. If, to avoid the latter, the collars are set far enough apart to have the laterally flowing material just touch the collars, then the material is torn at the edges. The deformation which brings about this undesirable result comes about as follows: As the material is compressed (see Fig. 3), it bulges out at the sides. The material which is not section-lined is elongated (in the direction of rolling) by compression. The material in the cross-sectioned portion, on the contrary, is **not** elongated in the direction of roll-

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ing (which in this illustration means at right angles to the paper) by **compression,** but solely by **shear** and resulting tension. The elongation of the central portion drags it along.

Limitations in Materials.

The action is somewhat similar to that going on in a piece of steel which is being bent over sharply (see Fig. 4). The neutral axis determines the length, and the other layers are lengthened by virtue of being part

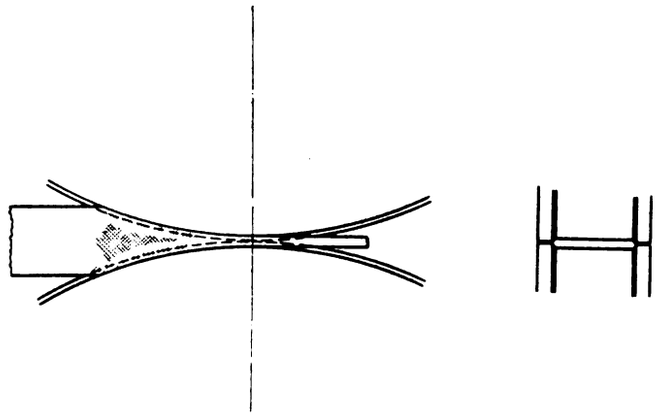

Fig. 2.—Action of spreading in rolling with very great reduction.

of the bar. Cracks appear, as indicated, unless the material is very ductile. In rolling the elongation is much more severe. In the bending test the length of the outer fiber is not quite doubled, whereas in the rolling problem under consideration the length of the outer fiber is increased to almost seven times its original dimension. While hot steel is more ductile than cold steel, the time available for deformation is much shorter in the rolling mill than it is in the cold bending test. It is known that, in the deformation of plastic bodies, high speed of deformation requires greater forces (see **Blast Furnace and Steel Plant**, May, 1915) which may easily exceed the rather low tensile strength of the hot steel.

Practical observation tells us that this action really occurs. It is not a theory, it is a condition. If small blooms are rolled into sheet bars in successive passes without edging, or side work, the total deformation in 5 to 8 passes is about the same as that which in our problem is attempted in one pass. Thus 6½-in. x 6½-in. is frequently rolled into 8-in. x ¾-in. The resulting sheet bars are far from satisfactory. The edges are full of fine hair cracks which show up badly in the finished sheets. To avoid these cracks, practice starts with a sheet bar slab about 2½-in. thick, or else puts side work on the bar, as will be explained later. Now it should be noted that the starting of hair cracks must be more severe in one very heavy reduction than it is with several passes of medium heavy reductions, for this reason: Spreading is more uniform over the whole section in the latter case, whereas the center bulges out the more the heavier the reduction. (A discussion of this difference was given by the author in **Blast Furnace and Steel Plant** for March, 1915. It will be amplified upon in the next installment of the present treatise.)

Similar difficulties would arise if it were attempted to roll a 7-in. x ¾-in. bar into a 1-in. square. It just cannot be done in one pass. As before, the collars can only be ½-in. deep at the utmost, and the bar would spread in the center way beyond the limits of the collars, making the final section almost "all fin".

Machinery and Power Problems.

From the foregoing it is evident that ductility of the stock, and lateral spreading of stock in rolls place limitations on the reduction per pass. Just where the limits are, will become clearer from later pharagraphs of this treatise. For the present it may be stated that it is not wise to go beyond 50 per cent reduction (which means an elongation of 2) except under very favorable circumstances.

Returning to other features limiting reduction, mention should be made of the fact that in heavy sections the available motive power must be reckoned with. If, for instance, an ingot is to be rolled in a three-high blooming mill, the reduction per pass seldom is more than 10 per cent or 11 per cent. If a reduction of 50 per cent were attempted, the rolls would have to be very large, the housings, shafts and pinions would assume tremendous proportions, and very heavy gearing would have to be placed between motor

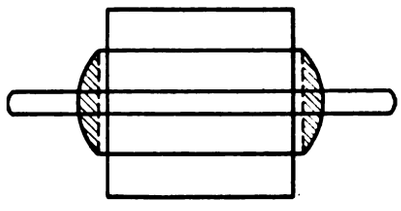

Fig. 3.

Diagrammatic illustration of portion of metal not subjected to compression in rolling process.

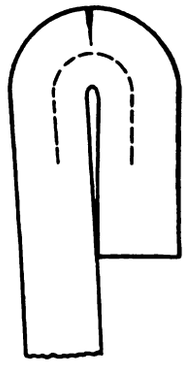

Fig. 4.

Cracking of material in cold bending test.

and mill. The cost would be prohibitive. When it comes to these heavy sections the roll designer must, in the case of a new mill, yet to be constructed, be guided by the consideration that maximum output is to be obtained for a given investment, or else that, for a given output, the investment shall be as small as is compatible with safety. If the mill is already in existence, he must keep the reduction within the limits

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of the strength of rolls, housings and pinions, and within the range of power of the motor or engine.

The same is true with regard to medium and small existing mills. Here, too, the roll pass designer must carefully consider the strength of the mill and of the drive. Some safety must be allowed on account of variations in temperature of the steel and on account of the practice of the rollers of occasionally passing steel through the mill, when it is colder than it should be for safety of the mill. Data on forces acting between stock and rolls, and on roll train resistance may be found in the author's series of articles on that subject in **The Blast Furnace and Steel Plant,** 1915..

Next month's contribution will deal in detail with the lateral spreading of the steel in the rolls under different conditions of speed, temperature, reduction and of shape of pass.

Rolling Wide Flanged Beam Sections

Three Types of Universal Mill Products—Theory and Practice in Production of Gray, Sack and Puppe Sections—Flange Characteristics Contrasted—Stress Problems Raised in the Various Designs

By F. DENK.

In previous issues of **The Blast Furnace and Steel Plant** from November 1916 to May 1917 a description of the different mills for rolling flat flanged beams was given. Of all the mills illustrated, only three types are still in operation, i.e. the Grey mill, Sack mill and Puppe mill, as was stated in the May issue (page 203). The Slick mill, also mentioned on page 203, will not be considered here, as the mill, being a three-high mill, rolls only small sizes up to 10 inches, which are mostly used for special purposes,—for instance as mine timbering. In the following, the sections rolled in the universal mills, enumerated above, will be described.

When designing shapes for beams, the main difficulty will be encountered in satisfying simultaneously the specifications and instructions of the customer as well as the demand of the roll designer. It is not only necessary to give the section such a shape that it can be rolled at all but it must also be possible to roll it in such a way that the material will not be damaged during the rolling process. For this reason mill designers have attempted to improve the sections of the beams keeping in mind if possible, to change the design of a section which is unfavorable for rolling into one which causes less cramping and straining of the material thus avoiding internal stresses either entirely or at least to a certain extent; this changing undoubtedly means an innovation which, in turn may under certain conditions mean a very important and essential technical progress.

The known forms of wide flanged beams which are rolled in universal mills are illustrated in Fig. 1. "**A**" represents a section of a Grey beam, as it is rolled in Differdingen, Luxemburg. This shape has a uniform slope of the inner flange-faces of 9 per cent, while the shapes rolled in the Grey mill at South Bethlehem, Pa., have a uniform slope of only 2 per cent. "**B**" illustrates a section of a Sack beam, having entirely parallel flange-faces. "**C**" shows a section, patented in Austria, which also has parallel faced flanges; in this case, however, a part of the inner flange is raised, thus making this flange thicker toward the web. This section is only mentioned and shown as an illustration of what has been developed in regard to the shapes o wide flanged, parallel faced beams, in order to overcome the difficulties encountered when using standard sections. It is not known to the writer if this shape was ever rolled or if developed only on paper, like the Goebel section (see March 1917 issue, pag 103); for this reason, only brief mention will be made of it below. Fig. 1, "**D**", shows a section of a Puppe beam, which has flanges the faces of which are parallel from the edge to a certain distance from the web. From there on the inner faces slope with a certain percentage towards the web. This percentage of slope is variable and can be made to suit any conditions.

The section most fit for making connections is, no doubt, the Sack section, shown in "**B**". It is possible to connect plates to the inside of the flanges, without having to bend them, as is necessary when using a section with a large slope—for instance a Differdingen-Grey section. On sloped flanges connection can be made only by means of bolts when bevelled washers are applied; when using rivets, the rivet heads, locate at the inner flange faces, cannot be driven flush on account of the slope. This is a decided disadvantage in cases, where the riveted structure is supposed to be completely water tight as for instance in ships and on docks.

These disadvantages are overcome, it is true, with Sack beams, but they are subject to other ones. Attention must be called to the unfavorable strains caused during rolling at the intersection between web and flanges. The cramping and crowding of the

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material during the rolling process at these places becomes the larger, the wider the flanges are to be made and, therefore, wide flanged beams with entirely parallel faces are the most disadvantageous in this respect, whereas shapes like "**A**" having sloped flange faces on the inside are designed much more favorably in regard to internal stresses.

The harm done to the quality of the material at the interesection of web and flanges becomes more significant when it is considered that, when loading the beam, the strains due to loading become unfavorable especially at this place. Simultaneously, shearing and transverse stresses appear through the combination of which strains are set up which may become, under certain circumstances, even higher than the allowable stresses in the external fibres. Wide flanged beams with entirely parallel faces are especially subject to these unfavorable conditions, because, naturally, the shearing stresses at the intersection between web and flanges are considerably higher than in beams with sloped flange faces.

There is however, another disadvantage connected with Sack sections in regard to internal stresses and this is due to the unsymmetrical rolls. These rolls (see January 1917 issue) develop a section which has a tendency to bend sideways after leaving the rolls and this tendency must be prevented by powerful guides which have to be applied at least in the case of the heavier beams thus forcing the beams into a straight form which cannot be done without again creating internal strains.

All this tends to show that in regard to internal stresses a Sack section is not as good as a section with uniformly sloped flange faces like a Grey section, because in the latter case the dangerous point, that is the point at the intersection of web and flanges, is closer to the neutral axis of the section than in the former case and this causes the transverse stresses to become smaller. It must also be kept in mind that any change made in the shape of the section of the beam has a harmful influence on the distribution of the internal stresses whenever the beams become loaded. The assumptions made for the calculation of the section do not hold good any more all the way through and the internal stresses may actually be higher than the calculation shows. Smoothing out the sharp edges by using a sloped face has, no doubt, a favorable influence, not only upon the rolling, but also upon the strains which are caused by loading the beam.

A further disadvantage of beams with entirely parallel flange faces is due to the following conditions. Beams, as a rule, are loaded uniformly over their whole surface which has the tendency to bend the flanges in a direction vertical to the longitudinal axis of the beam. Naturally the additional stresses generated by the bending forces are much more significant on wide flanged beams than on those with standard flanges. The bending moment increases towards the web. It is, therefore, of advantage to increase the thickness of the flanges towards the web. This shows that a section, like the one shown in Fig. 1, "**A**", is superior to the one illustrated in Fig. 1, "**B**", in which latter the additional fibre stresses may become quite considerable.

The above proves that a section with a uniformly sloped inner face is less subject to internal stresses than one with entirely parallel faces (other conditions to be equal, of course). On the other hand a section

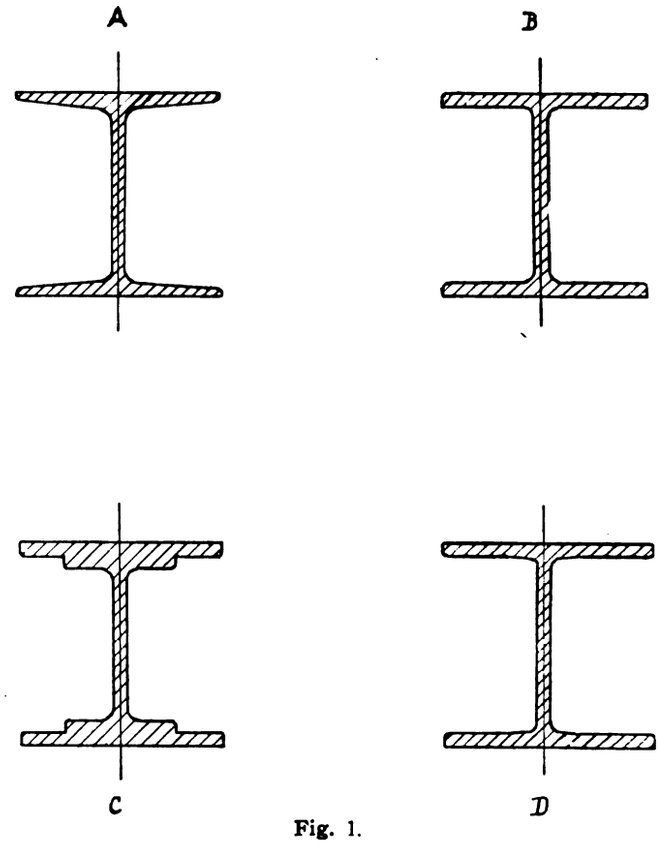

Fig. 1.

of the last named type is better for making cross connections than one of the first mentioned type. Each one of these shapes, therefore, has its advantages and its disadvantages.

It must furthermore be mentioned that a section with a uniform slope of 9 per cent is better as far as internal stresses are concerned than one with a uniform slope of 2 per cent, provided the average thickness of the flanges, i. e. the thickness halfway between web and edges is the same in both cases, because the distance of the dangerous point from the neutral axis is, in the case of the 9 per cent slope, smaller than in the case of the 2 per cent slope. On the other hand the section with only 2 per cent slope is better fit for making cross connections than the one with 9 per cent slope.

To overcome all these disadvantages the section

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shown in Fig. 1, "C", was developed. This section, as was stated above, is covered by an Austrian patent and is supposed to combine the advantages of sections "A" and "B" and to eliminate their disadvantages. This, however, can be only partly effected. It remains doubtful if by increasing the thickness of the flanges near the web the desired result in regard to the cramping and crowding of the material and in regard to damaging the quality during rolling can be obtained. The connection between web and flanges is made here like on section "B", under a right angle. But this way of joining web and flanges is just causing this decrease in the quality of material during rolling although in both cases in "B" as well as in "C" the disadvantage is slightly counteracted by a small fillet. The favorable result which is obtained in beams of the type "A" by connecting the inside of the flanges to the web under an obtuse angle is, no doubt, not effected in the case of type "C".

The section can, however, be used to better advantage for making cross connections than one like "A". There are no beveled washers necessary for bolt heads; rivet heads can be driven flush with the inner face of the flanges thus making a good and rigid connection. Some difficulty will be encountered when plates are supposed to be connected to the inner flange faces. These plates must either be short enough only to cover the thinner (outer) part of the flanges, or, if they are wanted to cover the full width, filler plates must be used for the outer part.

In regard to the transverse bending stresses section "C" is about as good as the one illustrated in "A" although the latter form follows more closely the increase of the bending moment.

Fig. 1, "D", shows a section of a Puppe beam, which combines the advantages adherent to sections "A" and "B" somewhat better than section "C", at the same time avoiding the disadvantages of these shapes. Cramping and crowding of the metal during rolling is as far as possible eliminated, due to the short sloped part of the flanges through which the latter are connected to the web under an obtuse angle. In this respect there can be obtained even an improvement over shape "A", by increasing the slope of the Puppe section without changing the length of the sloped part. Such an increase can easily be applied here

Compared with section "B", section "D" can be rolled in such a way that the internal stresses at the intersection between web and flanges are smaller. This can be accomplished without difficulties by increasing also the slope because increasing this slope will bring the dangerous point closer to the neutral axis. On section "D", the sloped connection on the parallel faced part even in case of the smallest section rolled of this type (about 7-in. x 7-in.) has a parallel flange piece which is large enough to use rivets of ¾-in. diameter.

CO-OPERATION AND THE MOBILIZATION OF PUBLIC SENTIMENT.*

By JOHN A. TOPPING,
Chairman, Republic Iron & Steel Company.

The President of the United States in his appeal, to awaken the Nation to its responsibilities urged that "we all speak, act and serve together" in response to our country's call. The President's appeal met a quick response from business, as evidenced by the mobilization of our financial, industrial, transportation, telephone and telegraph facilities, but our young men made a disappointing response to his urgent call for volunteers for army and navy service.

The lack of patriotic enthusiasm suggested by this experience is, I think, undoubtedly due to a lack of understanding by many of our people of the responsibilities of citizenship and of our national ideals. We cannot have unity of purpose, however, without a more thorough conception of individual responsibility; and to awaken this spirit of moral consciousness we must have a broader education of the people. In other words, if democracy as a governing force is to be effective, it can only be made so by qualifying the people through education, or by necessity, for their civic responsibilities. In no other way can legislative initiative be taken from the political demagogue. It required the stimulus and necessity of war to break down the traditions of the volunteer system. We are to be congratulated on this result, for we have obtained in exchange equal service, or selective draft, which means that the first gun has been fired for the principle of coöperation. And I believe the public mind is now in a receptive mood to apply this principle more broadly, not only through the reconstruction period after the war, as is proposed by the Lever Bill for the regulation of commodity prices, but for an indefinite period thereafter, if we inaugurate an earnest educational campaign for general coöperation.

Coöperation the Key.

Coöperation, in my opinion, is the key to the solution of most of our national and business problems. In recognition of this view, coöperation as a principle has been adopted by the leading nations of the world. Only recently Mr. A. Bonar Law announced in the House of Commons that preferential tariffs as a policy had been agreed to by Great Britain and her colonies, and that hereafter closer reciprocal treaties and coöperative methods would be worked out between them and their allies. England, notwithstanding the burdens of war, has, through coöperative methods, so coördinated her working forces that she has substantially maintained her normal over-seas trade and has also so effectually mobilized public sentiment favor-

* Extracts from address before the New York meeting of the American Iron and Steel Institute, May 25.

(Continued on Page 290.)

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Locomotive Shovel Plates From Old Tires

Adjusting Rolling Mill Equipment to Handle Scrapped Tires. Problems Arising in the Process—Preparing Rolls for Heavy Duty Requirements.

By W. S. STANDIFORD.*

In these days of efficiency methods, the conversion of worn waste materials into useful articles having different shapes, is receiving the attention of various mill and factory managers; as it is realized that a considerable saving in money can be effected by purchasing old worn metal, and re-rolling it to the desired sections.

Worn steel locomotive tires that have outlived their usefulness in that particular field, when rolled into shovel plate, make most excellent shovels; for the quality of the steel is of a very high grade and better suited to the rough usage that the average shovel receives or than one made from new steel containing a lower carbon content.

As the tires are of a circular section, they will have to be cut into halves before they can be used in the rolls; which can be done by sawing them either cold or hot. The method used by one rolling mill is as follows: A heavy cast iron plate having two projecting lugs on its surface opposite each other is secured to a suitable foundation, and placed in a horizontal position with the lugs facing upwards.

Fastened to the plate at a suitable distance is a hydraulic jack, so arranged that its plunger will exert pressure against the tire. The operating lever being connected to a small steam engine. The tire is placed in the frame and nicked at the sides with a cold chisel, the engine then being started. In a very short time, the tire separates into two halves; breaking at the nicked parts.

A number of them are then put into the heating furnace, and heated evenly through; it being most important that there should be no cold spots on the steel, as it interferes with the proper working of the metal in the rolls. The roughing rolls shown in Fig. 1., are three-high; this enables them to reduce the metal very quickly while it is at a white heat.

There are different methods used to reduce the flange on the tire adopted by various mills; the designs of the rolls usually being such as is suitable to the engine power and other requirements of the plant. In the set shown in Fig. 1., the flange is rolled back into the main body of the tire; the sides of the pass having such a steep angles, as to allow the bar to spread sideways in it. The heated metal is pushed by the rougher into the deepest grooves in the rolls; it is then turned over before insertion into No. 2-pass; this allows any impurities in the steel, which generally comes out on the surface in the form of scale to drop off. The scale is loosened from the bar by small streams of water flowing on the steel while it is in the rolls. The action of the latter on the metal in the first pass also straightens the steel out in bar form, which makes the handling of it in the other passes easier. As the steel goes through each groove, it is made thinner, wider and also lengthened—these depending upon the amount of carbon and also the quality of the metal.

Locomotive tires used to be made out of crucible steel, but they are rolled out of open hearth steel nowadays, as it has been found out by experience, that the open hearth process makes good reliable tires. After rolling, the bars being about 8-inches wide by 3/8 of an inch thick are cut into suitable lengths about two-feet long, and put into a heating furnace and re-heated. They are then ready for the sheet roughing rolls illustrated in Fig. 2. Each one is 36 inches long and 2 inches in diameter, and made of chilled iron; also being turned with level surfaces.

The two foot long bar is given two passes crossways in the rolls, the screws being worked at each pass. The cross rolling that the metal receives, makes it wider; the length being nearly the same. It is then turned at a right angle to its previous position, and given one pass lengthwise through the rolls; the latter being lowered before the steel is run through.

The bar is now about 1/8 of an inch thick and is ready for the finishing rolls depicted in Fig. 3. These rolls are 22-inches in diameter by 26-inches long. As will be noted in the illustration, one roll is turned straight, while the other has a concave surface. The amount of roll curvature shown on the drawing is purposely exaggerated, in order to make the picture clearer. The actual amount of surface curvature at its deepest part, being about six one-thousandths of one inch.

It has been found out by experience, that the thinner the plate rolled, the more concave the roll surface should be. This is in turn modified by such factors as the proportions of the diameters of the rolls to their body length. The gauge of plates rolled and also whether they are operated with or without streams of water flowing on them. The speed of rotation also has its influence on their smooth working.

The reason why they require to be turned hollow,

* Youngstown, Ohio.

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is that they expand by the heat, the center of a roll being actually larger in diameter than the parts at either ends of the roll body. By having a sufficient curvature, they expand so that their surfaces are straight and level. If a set of sheet rolls were turned level and used to make thin sheets, the latter would buckle badly and be useless. It will be noticed in Fig. 3., that only one roll has a concave surface—the other being turned straight.

In practice, both rolls could be turned with curved surfaces; in this case, it would be necessary to divide the total depth at the deepest part of the rolls (which is the middle of them) between the two rolls. They would then possess straighter peripheries, the curve not being so deep. By the use of rolls turned either way plates free from buckling are obtained.

From an economical standpoint, it is found quicker and cheaper to turn one roll straight, and the other concave, as it would take nearly double the time to turn both rolls with a curved surface than it would require to finish one. It taking very careful and accurate turning on the roll turners part to make them operate smoothly in the mill.

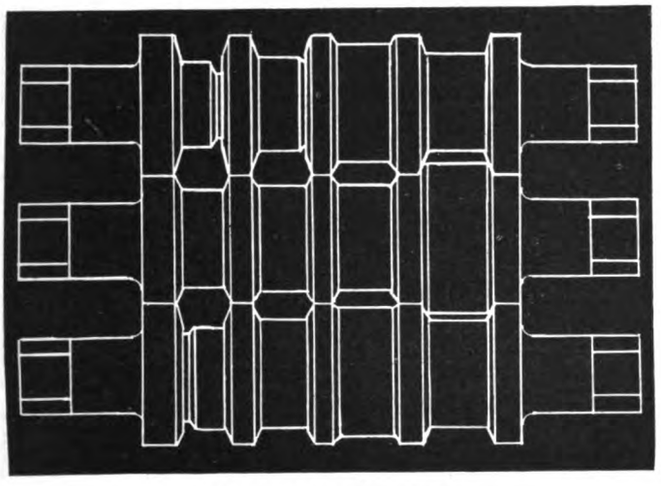

Fig. 1.—Roughing Rolls.

Having described the reasons for curving the surfaces of the finishing rolls, we will now take up the rolling of the steel to the desired gauge. The metal is transferred from the number 2-set to the number 3-ones. It is given three passes lengthwise; the screws being worked after each reduction until a thickness of 1/16 of an inch is reached. After each heat is over, water is turned on the number 2-set of sheet rolls; the number 3-finishing set are worked with a continuous flow of water in small streams while they are in operation. In shovel plate manufacture, it is desirable to keep the rolls working in the housings as long as possible. As a general rule, the surface of the rolls wears hollow in the middle long before their center surfaces get too rough to make good plates. This necessitates frequent dressing, which takes time and costs money.

In order to make them last as long as possible, one company devised a rigging which attaches to the front of the housings, whereby wooden blocks fed with emery powder are pressed against the bodies of the rolls, a short distance from each end, next to the necks. This prevented them from getting too deep in the center. The rolls were ground every Saturday afternoon, after the days work was done; the method proving very effective.

The number 2-set were in the housing five weeks before requiring dressing. The number 3-finishers are also scoured with emery when they require it. The emery scouring method enables both sets of rolls to be kept longer in the housing than would be the case if it were not used. Rolls for making tin plates, which are very thin in gauge, are also turned concave. These rolls need more surface curvature, as they expand considerably by the heat.

Tin plate rolls are usually from 24 to 26 inches in diameter, the length varying. A roll 24 inches in diameter by 32 inches length of body, should be turned 1/16 of an inch deeper in the middle, (measured by a calipers) than at the ends next to the necks. In other words the depth of curvature at the lowest part of the roll, should be 1/32 of an inch on each side of the roll.

If they are more than 24 inches in diameter, more concaving should be allowed. The temperature at which iron and steel is finished, is of great importance to the appearance of the product. Too high a finishing temperature will cause a thin layer of scale, which a strain of bending will make break away from the metal and leave rough spots, the appearance of the sheet being spoiled. Too low a finishing temperature on the other hand, will yield a spotty-reddish surface, which is prone to oxidize or rust.

Present-day methods used by the roll turner to turn the proper curvature on the one roll will be interesting to the readers of this magazine, as showing the manner in which the work is done. The first thing done, is to turn one roll level so that when a straight-edge has chalk rubbed on the edge, the superfluous amount being blown off by the breath, and the straight-edge placed carefully on the roll and rubbed lengthwise; the chalk will make a line on the roll, touching at all places if the turning has been carefully done.

The roll is then taken out of the lathe, and the one to be turned with a curved surface put in the machine. The other roll is placed in the carriage and put on top of the one in the lathe. The top roll carriage containing it is now moved 2⅝ inches to one side, (measured from the center on the end of the roll in the lathe) and fastened in that position. The middle of the roll on top being put as close as possible without touching the roll in the lathe. The turning of it is now begun from

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the middle; cuts about 1½ inches wide are made until the roll has a uniform concave surface, so that when the top roll in its diagonal position, is allowed to rest upon the bottom one, no light can be seen between them. It is then finished and ready for the mill.

When newly turned rolls for making thin sheets such as tin plates, are put in the mill, or are started on a Monday morning it is necessary to bring them to their maximum temperature before wide sheets can be rolled. This is done by rolling narrow ones, until the rolls have expanded sufficiently to make perfect plates. Turning of sheet rolls is a tedious process, and attempts have been made to do this work by means of specially constructed grinding machines. This is a great success, both from an economical standpoint as well as a quality one—the work being done in one-half the time that it takes a roll turner to do it, while the rolls have a smoother finish and are more accurate in every respect. Sometimes a jam in the rolls will cause what is technically termed a "burnt spot." Its shape varies, depending upon the form of the material rolled. In sheet rolls it takes the form of a long streak of compressed chilled iron, extending parallel to the axis of the roll. Its depth being about one-eighth of an inch.

Chilled cast iron is the hardest metal that the roll turner has to turn. The tool used to do the work is very little harder than the chilled iron, so that the periphery of the roll being turned, has to revolve at a speed of one-half a revolution per minute. When a burnt spot is encountered, the edge of the tool breaks

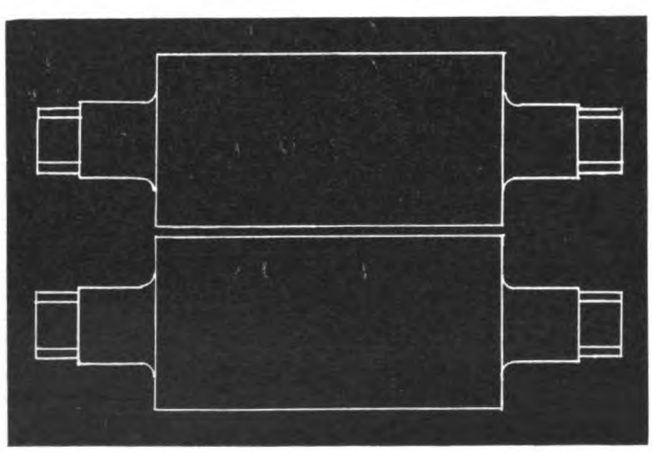

Fig. 2.— Sheet Roughers.

out and it slides over the spot and refuses to cut. All the roll turner can do when he discovers a burnt spot, is to re-sharpen the tool, put it in the lathe and when the burnt spot nears, to take a very heavy cut, so as to get under it and lift it out.

When it is one-eighth of an inch deep, it has to be broken down a small amount at a time, until it is finally removed. Doing this work is very tedious; and after it is done, the roll is made from ¼ to ⅜ of an inch smaller in diameter, the metal being wasted. From the foregoing, it will be seen that it is necessary to turn a burnt spot entirely out of the roll—thus wasting time and money, when a sheet roll is turned in the ordinary way. On the other hand, when a roll grinder is used, the emery wheels being very much harder than the roll, the burnt spot is easily trued up with the rest of the roll surface; only enough metal being removed to true the surface.

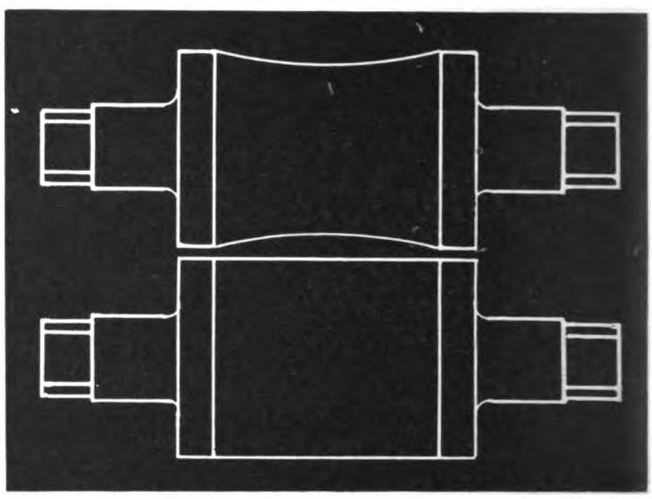

Fig. 3.—Sheet Finishing Rolls.

In conclusion, old locomotive tires besides making shovel and nail plates can be made into other useful sections, the metal having such a uniform texture and excellence, as to be made by the aid of rolls into quite a variety of shapes.

Government Research on Uranium Steel.

Two patents to Charles L. Parsons, Chief Chemist of the Bureau of Mines, Department of the Interior, and dedicated for the free use of the people, have been granted for a process for the purifying of uranium compounds and for a process for preparing oxides of uranium.

The process for the preparing of uranium oxide is of especial importance at this time owing to the fact that it is now definitely known that the Germans are using uranium steel in some of their large cannon, and this process will enable pure black oxide of uranium to be obtained for the use of producing ferro-uranium. Experiments in the production of uranium steel itself are now under way. By the use of the processes above mentioned the production of pure oxide of uranium is very much facilitated and cheapened. Also the product is obtained in a much purer form than has ever been acquired heretofore. In connection with the uranium work of the bureau considerable quantities of uranium were produced last year at the Bureau's Denver (Col.) plant, and the methods here referred to permit this to be converted into useful forms for commerce.

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*Strength and Inner Structure of Mild Steel**

Study of Cementite and Pearlite Combinations, and Their Evolution During Heat Treatment—Action Under Cooling Processes Must Be Traced Before Absolute Data Can Be Obtained.

By PROF. W. E. DALBY, M. A., F. R. S.

In recent years the study of the inner structure of metals has changed from an interesting research in pure science to an industrial research of profound importance to engineers.

Knowledge of the inner architecture of metals is steadily being accumulated; the effect of heat treatment on the style of the architecture; the true nature of alloys, and the true nature of solidification of metals.

My object in this paper is to illustrate the inner structure of ordinary steel and to show how its strength is correlated with this inner structure.

A metal solidifies by a process of crystallization. The process starts at innumerable points or nuclei distributed through the mass and tranforms the liquid metal surrounding each nucleus into a crystal block. Every individual block is formed of crystal bricks set side by side in regular geometrical formation along axes of growth belonging to the order in which the metal crystallizes. The outer and visible form of a crystal growth which has grown in freedom shows the geometrical form of the minute crystals of which it is built. But the outer and visible form (visible, however, only in the microscope) of a crystal block grown in a crowd of other growing crystals bears no sort of resemblance to the minute crystals of which it is built. The blocks, microscopic in size, are roughly ploygonal; rough boulder- shaped; sharp or blunt edged; or branched like a coral or fir-tree, according to the metal and the circumstances of the soldification and the rate at which heat is abstracted from the cooling metal. Each crystal growth feeds upon an ever-diminishing supply of liquid material in the presence of the gradual approach of the solid walls of the growing crystals in its neighbourhood. The final shape of a crystal block is thus the result of the arrested growth, first in one direction and then in another direction, owing to the failure of the liquid supply and the obstruction of the crystal walls of its neighbours.

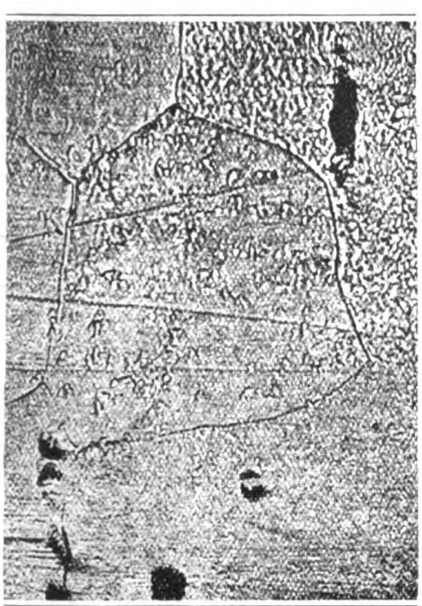

Fig. 1.—Magnified 1,000 diameters.

Fig. 2.—Magnified 200 diameters.

Fig. 3.—Magnified 1,000 diameters.

Growth does not start from the primitive points or nuclei in parallel directions, although the axes of growth are at every point geometrically similar in their relative directions. Axes of growth tend to set at right angles to the surfaces across which heat is escaping, but in the interior of a mass the directions of the axes of the crystal blocks are all to appearance quite haphazard.

Structure Modifications.

Iron and steel in the manufactured condition have

* From a paper read before the Institution of Naval Architects, London, England, March 28, 1917.

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material during the rolling process at these places becomes the larger, the wider the flanges are to be made and, therefore, wide flanged beams with entirely parallel faces are the most disadvantageous in this respect, whereas shapes like "**A**" having sloped flange faces on the inside are designed much more favorably in regard to internal stresses.

The harm done to the quality of the material at the interesection of web and flanges becomes more significant when it is considered that, when loading the beam, the strains due to loading become unfavorable especially at this place. Simultaneously, shearing and transverse stresses appear through the combination of which strains are set up which may become, under certain circumstances, even higher than the allowable stresses in the external fibres. Wide flanged beams with entirely parallel faces are especially subject to these unfavorable conditions, because, naturally, the shearing stresses at the intersection between web and flanges are considerably higher than in beams with sloped flange faces.

There is however, another disadvantage connected with Sack sections in regard to internal stresses and this is due to the unsymmetrical rolls. These rolls (see January 1917 issue) develop a section which has a tendency to bend sideways after leaving the rolls and this tendency must be prevented by powerful guides which have to be applied at least in the case of the heavier beams thus forcing the beams into a straight form which cannot be done without again creating internal strains.

All this tends to show that in regard to internal stresses a Sack section is not as good as a section with uniformly sloped flange faces like a Grey section, because in the latter case the dangerous point, that is the point at the intersection of web and flanges, is closer to the neutral axis of the section than in the former case and this causes the transverse stresses to become smaller. It must also be kept in mind that any change made in the shape of the section of the beam has a harmful influence on the distribution of the internal stresses whenever the beams become loaded. The assumptions made for the calculation of the section do not hold good any more all the way through and the internal stresses may actually be higher than the calculation shows. Smoothing out the sharp edges by using a sloped face has, no doubt, a favorable influence, not only upon the rolling, but also upon the strains which are caused by loading the beam.

A further disadvantage of beams with entirely parallel flange faces is due to the following conditions. Beams, as a rule, are loaded uniformly over their whole surface which has the tendency to bend the flanges in a direction vertical to the longitudinal axis of the beam. Naturally the additional stresses generated by the bending forces are much more significant on wide flanged beams than on those with standard flanges. The bending moment increases towards the web. It is, therefore, of advantage to increase the thickness of the flanges towards the web. This shows that a section, like the one shown in Fig. 1, "**A**", is superior to the one illustrated in Fig. 1, "**B**", in which latter the additional fibre stresses may become quite considerable.

The above proves that a section with a uniformly sloped inner face is less subject to internal stresses than one with entirely parallel faces (other conditions to be equal, of course). On the other hand a section

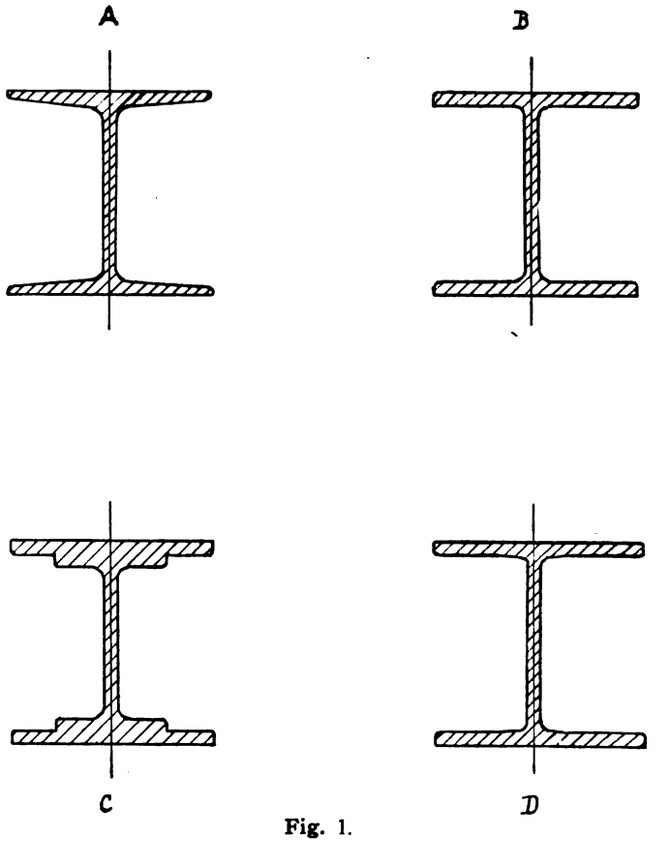

Fig. 1.

of the last named type is better for making cross connections than one of the first mentioned type. Each one of these shapes, therefore, has its advantages and its disadvantages.

It must furthermore be mentioned that a section with a uniform slope of 9 per cent is better as far as internal stresses are concerned than one with a uniform slope of 2 per cent, provided the average thickness of the flanges, i. e. the thickness halfway between web and edges is the same in both cases, because the distance of the dangerous point from the neutral axis is, in the case of the 9 per cent slope, smaller than in the case of the 2 per cent slope. On the other hand the section with only 2 per cent slope is better fit for making cross connections than the one with 9 per cent slope.

To overcome all these disadvantages the section

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shown in Fig. 1, "C", was developed. This section, as was stated above, is covered by an Austrian patent and is supposed to combine the advantages of sections "A" and "B" and to eliminate their disadvantages. This, however, can be only partly effected. It remains doubtful if by increasing the thickness of the flanges near the web the desired result in regard to the cramping and crowding of the material and in regard to damaging the quality during rolling can be obtained. The connection between web and flanges is made here like on section "B", under a right angle. But this way of joining web and flanges is just causing this decrease in the quality of material during rolling although in both cases in "B" as well as in "C" the disadvantage is slightly counteracted by a small fillet. The favorable result which is obtained in beams of the type "A" by connecting the inside of the flanges to the web under an obtuse angle is, no doubt, not effected in the case of type "C".

The section can, however, be used to better advantage for making cross connections than one like "A". There are no beveled washers necessary for bolt heads; rivet heads can be driven flush with the inner face of the flanges thus making a good and rigid connection. Some difficulty will be encountered when plates are supposed to be connected to the inner flange faces. These plates must either be short enough only to cover the thinner (outer) part of the flanges, or, if they are wanted to cover the full width, filler plates must be used for the outer part.

In regard to the transverse bending stresses section "C" is about as good as the one illustrated in "A" although the latter form follows more closely the increase of the bending moment.

Fig. 1, "D", shows a section of a Puppe beam, which combines the advantages adherent to sections "A" and "B" somewhat better than section "C", at the same time avoiding the disadvantages of these shapes. Cramping and crowding of the metal during rolling is as far as possible eliminated, due to the short sloped part of the flanges through which the latter are connected to the web under an obtuse angle. In this respect there can be obtained even an improvement over shape "A", by increasing the slope of the Puppe section without changing the length of the sloped part. Such an increase can easily be applied here

Compared with section "B", section "D" can be rolled in such a way that the internal stresses at the intersection between web and flanges are smaller. This can be accomplished without difficulties by increasing also the slope because increasing this slope will bring the dangerous point closer to the neutral axis. On section "D", the sloped connection on the parallel faced part even in case of the smallest section rolled of this type (about 7-in. x 7-in.) has a parallel flange piece which is large enough to use rivets of ¾-in. diameter.

CO-OPERATION AND THE MOBILIZATION OF PUBLIC SENTIMENT.*

By JOHN A. TOPPING,
Chairman, Republic Iron & Steel Company.

The President of the United States in his appeal, to awaken the Nation to its responsibilities urged that "we all speak, act and serve together" in response to our country's call. The President's appeal met a quick response from business, as evidenced by the mobilization of our financial, industrial, transportation, telephone and telegraph facilities, but our young men made a disappointing response to his urgent call for volunteers for army and navy service.

The lack of patriotic enthusiasm suggested by this experience is, I think, undoubtedly due to a lack of understanding by many of our people of the responsibilities of citizenship and of our national ideals. We cannot have unity of purpose, however, without a more thorough conception of individual responsibility; and to awaken this spirit of moral consciousness we must have a broader education of the people. In other words, if democracy as a governing force is to be effective, it can only be made so by qualifying the people through education, or by necessity, for their civic responsibilities. In no other way can legislative initiative be taken from the political demagogue. It required the stimulus and necessity of war to break down the traditions of the volunteer system. We are to be congratulated on this result, for we have obtained in exchange equal service, or selective draft, which means that the first gun has been fired for the principle of coöperation. And I believe the public mind is now in a receptive mood to apply this principle more broadly, not only through the reconstruction period after the war, as is proposed by the Lever Bill for the regulation of commodity prices, but for an indefinite period thereafter, if we inaugurate an earnest educational campaign for general coöperation.

Coöperation the Key.

Coöperation, in my opinion, is the key to the solution of most of our national and business problems. In recognition of this view, coöperation as a principle has been adopted by the leading nations of the world. Only recently Mr. A. Bonar Law announced in the House of Commons that preferential tariffs as a policy had been agreed to by Great Britain and her colonies, and that hereafter closer reciprocal treaties and coöperative methods would be worked out between them and their allies. England, notwithstanding the burdens of war, has, through coöperative methods, so coördinated her working forces that she has substantially maintained her normal over-seas trade and has also so effectually mobilized public sentiment favor-

* Extracts from address before the New York meeting of the American Iron and Steel Institute, May 25.

(Continued on Page 290.)

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Locomotive Shovel Plates From Old Tires

Adjusting Rolling Mill Equipment to Handle Scrapped Tires. Problems Arising in the Process—Preparing Rolls for Heavy Duty Requirements.

By W. S. STANDIFORD.*

In these days of efficiency methods, the conversion of worn waste materials into useful articles having different shapes, is receiving the attention of various mill and factory managers; as it is realized that a considerable saving in money can be effected by purchasing old worn metal, and re-rolling it to the desired sections.

Worn steel locomotive tires that have outlived their usefulness in that particular field, when rolled into shovel plate, make most excellent shovels; for the quality of the steel is of a very high grade and better suited to the rough usage that the average shovel receives or than one made from new steel containing a lower carbon content.

As the tires are of a circular section, they will have to be cut into halves before they can be used in the rolls; which can be done by sawing them either cold or hot. The method used by one rolling mill is as follows: A heavy cast iron plate having two projecting lugs on its surface opposite each other is secured to a suitable foundation, and placed in a horizontal position with the lugs facing upwards.

Fastened to the plate at a suitable distance is a hydraulic jack, so arranged that its plunger will exert pressure against the tire. The operating lever being connected to a small steam engine. The tire is placed in the frame and nicked at the sides with a cold chisel, the engine then being started. In a very short time, the tire separates into two halves; breaking at the nicked parts.

A number of them are then put into the heating furnace, and heated evenly through; it being most important that there should be no cold spots on the steel, as it interferes with the proper working of the metal in the rolls. The roughing rolls shown in Fig. 1., are three-high; this enables them to reduce the metal very quickly while it is at a white heat.

There are different methods used to reduce the flange on the tire adopted by various mills; the designs of the rolls usually being such as is suitable to the engine power and other requirements of the plant. In the set shown in Fig. 1., the flange is rolled back into the main body of the tire; the sides of the pass having such a steep angles, as to allow the bar to spread sideways in it. The heated metal is pushed by the rougher into the deepest grooves in the rolls; it is then turned over before insertion into No. 2-pass; this allows any impurities in the steel, which generally comes out on the surface in the form of scale to drop off. The scale is loosened from the bar by small streams of water flowing on the steel while it is in the rolls. The action of the latter on the metal in the first pass also straightens the steel out in bar form, which makes the handling of it in the other passes easier. As the steel goes through each groove, it is made thinner, wider and also lengthened—these depending upon the amount of carbon and also the quality of the metal.

Locomotive tires used to be made out of crucible steel, but they are rolled out of open hearth steel nowadays, as it has been found out by experience, that the open hearth process makes good reliable tires. After rolling, the bars being about 8-inches wide by ⅜ of an inch thick are cut into suitable lengths about two-feet long, and put into a heating furnace and re-heated. They are then ready for the sheet roughing rolls illustrated in Fig. 2. Each one is 36 inches long and 2 inches in diameter, and made of chilled iron; also being turned with level surfaces.

The two foot long bar is given two passes crossways in the rolls, the screws being worked at each pass. The cross rolling that the metal receives, makes it wider; the length being nearly the same. It is then turned at a right angle to its previous position, and given one pass lengthwise through the rolls; the latter being lowered before the steel is run through.

The bar is now about ⅛ of an inch thick and is ready for the finishing rolls depicted in Fig. 3. These rolls are 22-inches in diameter by 26-inches long. As will be noted in the illustration, one roll is turned straight, while the other has a concave surface. The amount of roll curvature shown on the drawing is purposely exaggerated, in order to make the picture clearer. The actual amount of surface curvature at its deepest part, being about six one-thousandths of one inch.

It has been found out by experience, that the thinner the plate rolled, the more concave the roll surface should be. This is in turn modified by such factors as the proportions of the diameters of the rolls to their body length. The gauge of plates rolled and also whether they are operated with or without streams of water flowing on them. The speed of rotation also has its influence on their smooth working.

The reason why they require to be turned hollow,

* Youngstown, Ohio.

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is that they expand by the heat, the center of a roll being actually larger in diameter than the parts at either ends of the roll body. By having a sufficient curvature, they expand so that their surfaces are straight and level. If a set of sheet rolls were turned level and used to make thin sheets, the latter would buckle badly and be useless. It will be noticed in Fig. 3., that only one roll has a concave surface—the other being turned straight.

In practice, both rolls could be turned with curved surfaces; in this case, it would be necessary to divide the total depth at the deepest part of the rolls (which is the middle of them) between the two rolls. They would then possess straighter peripheries, the curve not being so deep. By the use of rolls turned either way plates free from buckling are obtained.

From an economical standpoint, it is found quicker and cheaper to turn one roll straight, and the other concave, as it would take nearly double the time to turn both rolls with a curved surface than it would

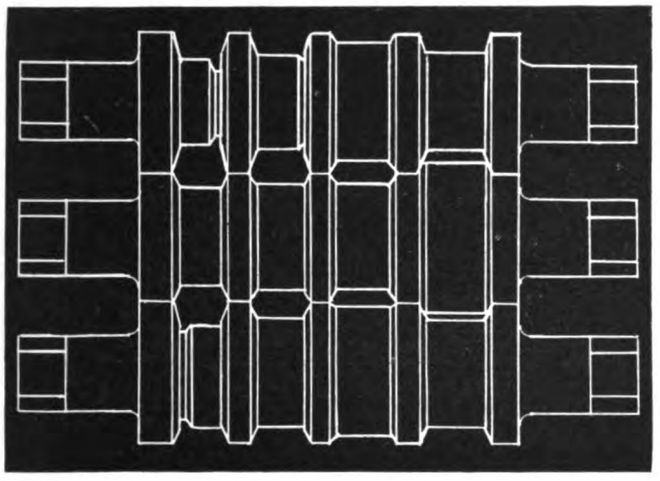

Fig. 1.—Roughing Rolls.

require to finish one. It taking very careful and accurate turning on the roll turners part to make them operate smoothly in the mill.

Having described the reasons for curving the surfaces of the finishing rolls, we will now take up the rolling of the steel to the desired gauge. The metal is transferred from the number 2-set to the number 3-ones. It is given three passes lengthwise; the screws being worked after each reduction until a thickness of 1/16 of an inch is reached. After each heat is over, water is turned on the number 2-set of sheet rolls; the number 3-finishing set are worked with a continuous flow of water in small streams while they are in operation. In shovel plate manufacture, it is desirable to keep the rolls working in the housings as long as possible. As a general rule, the surface of the rolls wears hollow in the middle long before their center surfaces get too rough to make good plates. This necessitates frequent dressing, which takes time and costs money.

In order to make them last as long as possible, one company devised a rigging which attaches to the front of the housings, whereby wooden blocks fed with emery powder are pressed against the bodies of the rolls, a short distance from each end, next to the necks. This prevented them from getting too deep in the center. The rolls were ground every Saturday afternoon, after the days work was done; the method proving very effective.

The number 2-set were in the housing five weeks before requiring dressing. The number 3-finishers are also scoured with emery when they require it. The emery scouring method enables both sets of rolls to be kept longer in the housing than would be the case if it were not used. Rolls for making tin plates, which are very thin in gauge, are also turned concave. These rolls need more surface curvature, as they expand considerably by the heat.

Tin plate rolls are usually from 24 to 26 inches in diameter, the length varying. A roll 24 inches in diameter by 32 inches length of body, should be turned 1/16 of an inch deeper in the middle, (measured by a calipers) than at the ends next to the necks. In other words the depth of curvature at the lowest part of the roll, should be 1/32 of an inch on each side of the roll.

If they are more than 24 inches in diameter, more concaving should be allowed. The temperature at which iron and steel is finished, is of great importance to the appearance of the product. Too high a finishing temperature will cause a thin layer of scale, which a strain of bending will make break away from the metal and leave rough spots, the appearance of the sheet being spoiled. Too low a finishing temperature on the other hand, will yield a spotty-reddish surface, which is prone to oxidize or rust.

Present-day methods used by the roll turner to turn the proper curvature on the one roll will be interesting to the readers of this magazine, as showing the manner in which the work is done. The first thing done, is to turn one roll level so that when a straight-edge has chalk rubbed on the edge, the superfluous amount being blown off by the breath, and the straight-edge placed carefully on the roll and rubbed lengthwise; the chalk will make a line on the roll, touching at all places if the turning has been carefully done.

The roll is then taken out of the lathe, and the one to be turned with a curved surface put in the machine. The other roll is placed in the carriage and put on top of the one in the lathe. The top roll carriage containing it is now moved 2⅝ inches to one side, (measured from the center on the end of the roll in the lathe) and fastened in that position. The middle of the roll on top being put as close as possible without touching the roll in the lathe. The turning of it is now begun from

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the middle; cuts about 1½ inches wide are made until the roll has a uniform concave surface, so that when the top roll in its diagonal position, is allowed to rest upon the bottom one, no light can be seen between them. It is then finished and ready for the mill.

When newly turned rolls for making thin sheets such as tin plates, are put in the mill, or are started on a Monday morning it is necessary to bring them to their maximum temperature before wide sheets can be rolled. This is done by rolling narrow ones, until the rolls have expanded sufficiently to make perfect plates. Turning of sheet rolls is a tedious process, and attempts have been made to do this work by means of specially constructed grinding machines. This is a great success, both from an economical standpoint as well as a quality one—the work being done in one-half the time that it takes a roll turner to do it, while the rolls have a smoother finish and are more accurate in every respect. Sometimes a jam in the rolls will cause what is technically termed a "burnt spot." Its shape varies, depending upon the form of the material rolled. In sheet rolls it takes the form of a long streak of compressed chilled iron, extending parallel to the axis of the roll. Its depth being about one-eighth of an inch.

Chilled cast iron is the hardest metal that the roll turner has to turn. The tool used to do the work is very little harder than the chilled iron, so that the periphery of the roll being turned, has to revolve at a speed of one-half a revolution per minute. When a burnt spot is encountered, the edge of the tool breaks

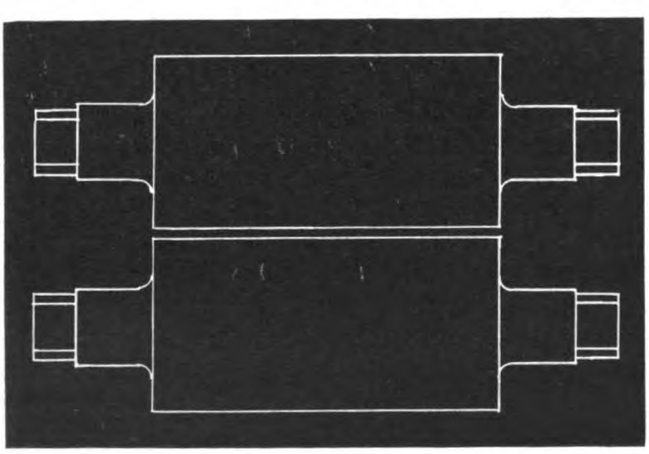

Fig. 2.— Sheet Roughers.

out and it slides over the spot and refuses to cut. All the roll turner can do when he discovers a burnt spot, is to re-sharpen the tool, put it in the lathe and when the burnt spot nears, to take a very heavy cut, so as to get under it and lift it out.

When it is one-eighth of an inch deep, it has to be broken down a small amount at a time, until it is finally removed. Doing this work is very tedious; and after it is done, the roll is made from ¼ to ⅜ of an inch smaller in diameter, the metal being wasted. From the foregoing, it will be seen that it is necessary to turn a burnt spot entirely out of the roll—thus wasting time and money, when a sheet roll is turned in the ordinary way. On the other hand, when a roll grinder is used, the emery wheels being very much harder than the roll, the burnt spot is easily trued up with the rest of the roll surface; only enough metal being removed to true the surface.

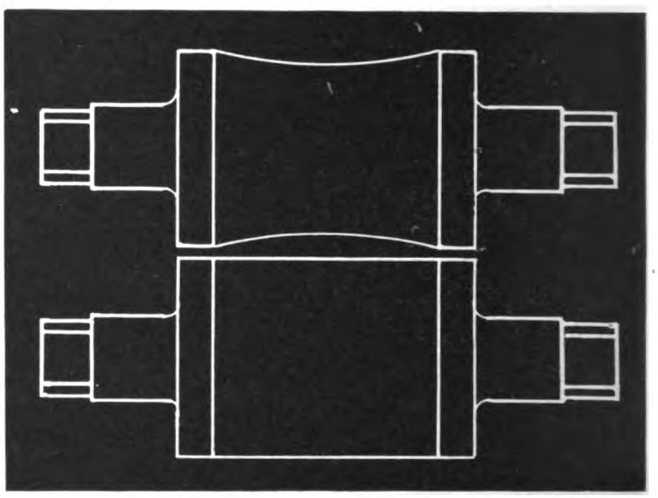

Fig. 3.—Sheet Finishing Rolls.

In conclusion, old locomotive tires besides making shovel and nail plates can be made into other useful sections, the metal having such a uniform texture and excellence, as to be made by the aid of rolls into quite a variety of shapes.

Government Research on Uranium Steel.

Two patents to Charles L. Parsons, Chief Chemist of the Bureau of Mines, Department of the Interior, and dedicated for the free use of the people, have been granted for a process for the purifying of uranium compounds and for a process for preparing oxides of uranium.

The process for the preparing of uranium oxide is of especial importance at this time owing to the fact that it is now definitely known that the Germans are using uranium steel in some of their large cannon, and this process will enable pure black oxide of uranium to be obtained for the use of producing ferro-uranium. Experiments in the production of uranium steel itself are now under way. By the use of the processes above mentioned the production of pure oxide of uranium is very much facilitated and cheapened. Also the product is obtained in a much purer form than has ever been acquired heretofore. In connection with the uranium work of the bureau considerable quantities of uranium were produced last year at the Bureau's Denver (Col.) plant, and the methods here referred to permit this to be converted into useful forms for commerce.

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*Strength and Inner Structure of Mild Steel**

Study of Cementite and Pearlite Combinations, and Their Evolution During Heat Treatment—Action Under Cooling Processes Must Be Traced Before Absolute Data Can Be Obtained.

By PROF. W. E. DALBY, M. A., F. R. S.

In recent years the study of the inner structure of metals has changed from an interesting research in pure science to an industrial research of profound importance to engineers.

Knowledge of the inner architecture of metals is steadily being accumulated; the effect of heat treatment on the style of the architecture; the true nature of alloys, and the true nature of solidification of metals.

My object in this paper is to illustrate the inner structure of ordinary steel and to show how its strength is correlated with this inner structure.

A metal solidifies by a process of crystallization. The process starts at innumerable points or nuclei distributed through the mass and tranforms the liquid metal surrounding each nucleus into a crystal block. Every individual block is formed of crystal bricks set side by side in regular geometrical formation along axes of growth belonging to the order in which the metal crystallizes. The outer and visible form of a crystal growth which has grown in freedom shows the geometrical form of the minute crystals of which it is built. But the outer and visible form (visible, however, only in the microscope) of a crystal block grown in a crowd of other growing crystals bears no sort of resemblance to the minute crystals of which it is built. The blocks, microscopic in size, are roughly ploygonal; rough boulder- shaped; sharp or blunt edged; or branched like a coral or fir-tree, according to the metal and the circumstances of the soldification and the rate at which heat is abstracted from the cooling metal. Each crystal growth feeds upon an ever-diminishing supply of liquid material in the presence of the gradual approach of the solid walls of the growing crystals in its neighbourhood. The final shape of a crystal block is thus the result of the arrested growth, first in one direction and then in another direction, owing to the failure of the liquid supply and the obstruction of the crystal walls of its neighbours.

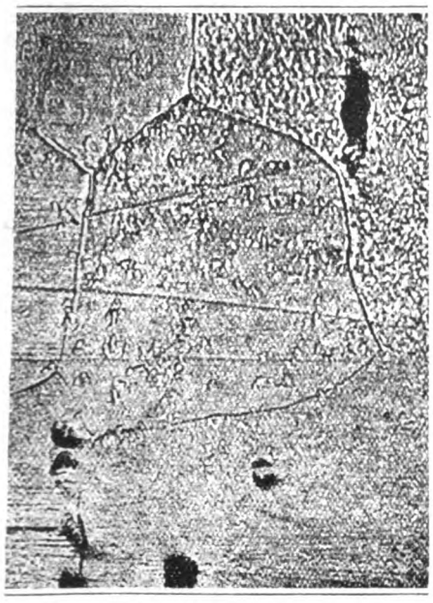

Fig. 1.—Magnified 1,000 diameters.

Fig. 2.—Magnified 200 diameters.

Fig. 3.—Magnified 1,000 diameters.

Growth does not start from the primitive points or nuclei in parallel directions, although the axes of growth are at every point geometrically similar in their relative directions. Axes of growth tend to set at right angles to the surfaces across which heat is escaping, but in the interior of a mass the directions of the axes of the crystal blocks are all to appearance quite haphazard.

Structure Modifications.

Iron and steel in the manufactured condition have

* From a paper read before the Institution of Naval Architects, London, England, March 28, 1917.

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passed through many processes of reheating, hammering, rolling, remelting and annealing, in consequence of which the crystal blocks of the final structure are not the primitive crystal blocks of solidfication but modifications of them, or rather other blocks grown from nuclei formed by the debris of the primitive blocks.

Fig. 1 shows the section of a crystal block as seen in the microscope on a polished and etched section of a piece of good quality Yorkshire iron cut across the direction of rolling. It is polygonal in shape, and measures on the original photographic plate 2.5 in. along the longest diameter, which lies diagonally from the top right to the bottom left. The block is magnified 1,390 times, so that the actual distance across is 1/550 in. A magnification of 1,390 is equivalent to stretching a yard into just over three-quarters of a mile. The figure is reproduced three-quarters the actual size of the original plate, so that as seen in Fig. 1 the magnification is about 1,000 diameters. The black areas in the figure show cross-sections of thread of slag, which are seen lengthways in Fig. 2. This figure shows the structure of the same material taken along the direction of rolling and magnified only 200 times. The block structure is clearly seen in this photograph.

The process of solidification of iron containing carbon is complex, and there is the added complication that the inner structure which exists just below the temperature of complete solidification changes as the temperature falls. The solid crystal blocks rebuild themselves into other shapes as the temperature falls, and, moreover, the final shapes of the blocks and their crystal structure depend upon the rate at which the temperature falls.

The inner structure of annealed steel as seen in the microscope appears as a conglomerate of iron blocks and pearlite blocks, or a conglomerate of cementite blocks and pearlite blocks. The iron in these structures is usually called ferrite.

Formation of Pearlite.

Pearlite is one of the most interesting metallic structures seen in the microscope. The polished and etched surface of a piece of annealed steel usually show sections of blocks of pearlite. Steel containing about 0.9 per cent of carbon is built of blocks of pearlite and nothing else. ,

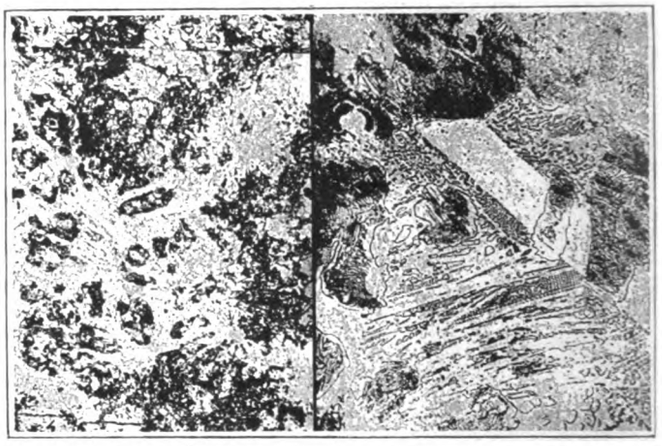

Fig. 4.—Magnification × 62. Fig. 5.—Magnified 250 diameters.

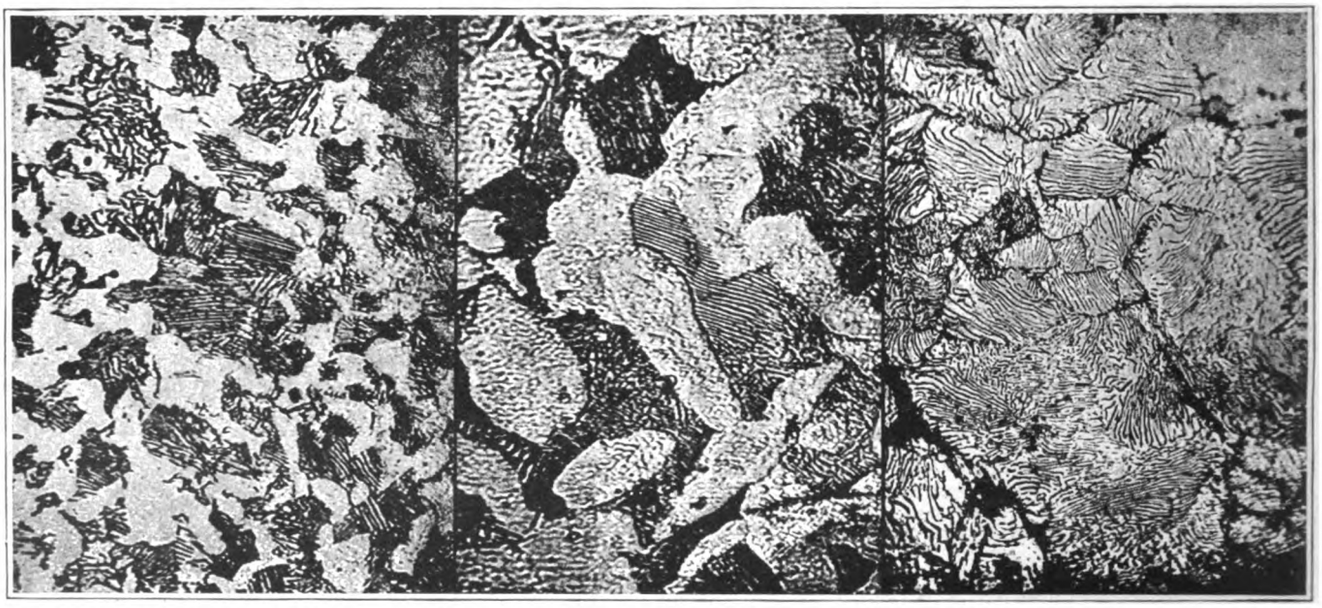

Fig. 6.—Magnified 1,000 diameters. Fig. 7.—Magnified 1,000 diameters. Fig. 8.—Magnified 500 diameters.

Pearlite is itself a conglomerate constructed of alternating sheets of iron and cementite. Cementite is the chemical compound of iron and carbon having the definite formula Fe_3C. Thin sheets of iron with thin sheets of cementite between them, packed closely together, 60,000 to the inch, form the substance of a pearlite block, and these packed sheets are bent in the pack into the shapes which suggest that the final

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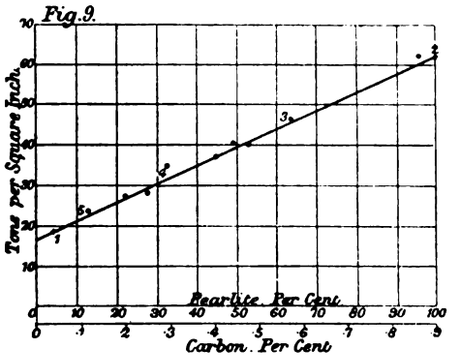
forms of the blocks seen in the microscope have been developed against a complicated play of internal molecular forces. Sections of these pearlite blocks seen in the microscope resemble certain sections of stratified rocks seen on a grand scale.

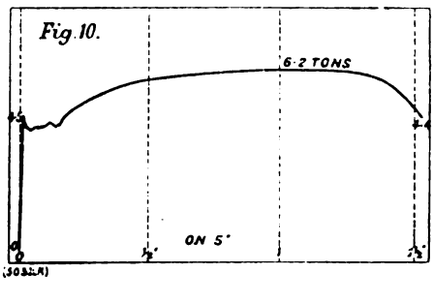
Fig. 3 shows the structure of a piece of steel built wholly of pearlite blocks. This specimen contains 0.9 per cent of carbon. The section plane cuts the curving sheets of the structure at all angles. Where it cuts the sheets at right angles they appear closely packed and of regular thickness, but this appearance merges into one of overlapping plates and scales as the sheets get more and more inclined to the section plane. The individual blocks of the structure can be made out, but their boundaries are rather indefinite. The large central group of blocks almost suggests the shape of an heraldic bird. From the tip of the tail vertically to the top of the head the distance is about 2.5 in. on the figure. The structure is magnified 1,000 times, so that the actual distance is about 1/400 in. At places where the sheets are most closely packed it is reasonable to suppose that they are cut square across, so that the actual thickness of a pair of them can be measured. The average thickness of a pair measured on the figure is 1/32 in. Therefore the actual thickness of a sheet of iron and a sheet of cementite next to it is of the order 1/32000 in.

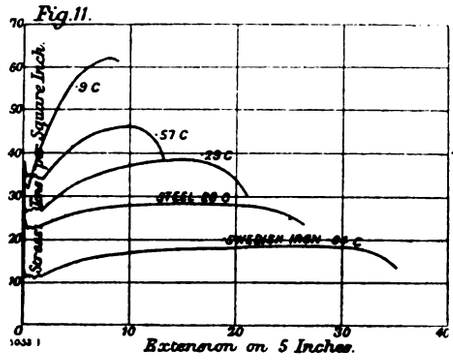
Block Structures.

The block structure is better seen in Fig 6, which shows a section of 0.57 carbon steel magnified 1,000 times. There is not enough carbon present to convert the whole of the iron into pearlite blocks. As much of it is converted as possible, and the iron left over appears as an element in the structure, so that what is seen in the microscope is a conglomerate structure of pearlite blocks and free iron blocks, though the etching has not been carried far enough to bring out the boundaries of the iron blocks. In some places single blocks of pearlite are seen; in other places groups of two and three blocks. The distribution of pearlite blocks is uniform and shows good material. The texture of the pearlite is rather finer than that measured in Fig. 3, being of the order 1/50000 of an inch.

In the section of a piece of 0.29 carbon steel shown in Fig. 7, magnified 1,000 times, a pearlite block of large size is seen isolated. Its greatest length is 1/700 of an inch, and the alternating sheets of iron and cementite show great uniformity and straightness. It looks as though the section caught the block squarely across the direction of the sheets. The thickness of a pair of sheets is rather more than in the previous example. The structures in Fig. 3, 6 and 7 are all of them of material which has been worked and treated. Fig. 8 shows the structure of a section of a piece of pig-iron. The magnification is 500. The area shown in the figure is in actual size about 1/30000 of a square inch. It is seen that this part of the metal is constructed entirely of blocks of pearlite. The shapes of these blocks indicate, however, the shapes of the primitive crystals formed on solidfication, because the metal has never been melted nor treated after solidification. The pearlite appears to be rather coarser than that seen in the steel structure illustrated in Figs. 3, 6 and 7. The closest packing in the area measures about 30,000 pairs of sheets to the inch. This metal is the first product of the blast furnace, and yet it exhibits amongst its structural elements pearlite blocks, the building material of fine steel. Pig iron shows other kinds of blocks in other areas, and I will return to the general structure of this iron presently.







Pearlite-Carbon Ratios.

The chemical formula for cementite, namely Fe_3C, shows that cementite consists of 168 parts by weight of iron and 12 parts by weight of carbon, corresponding to 1 part of carbon and 14 parts of iron in 15 parts of cementite. Therefore 0.9 part of carbon form with 12.6 parts of iron 13.5 parts of cementite. Analysis of pearlite shows that the blocks contain 0.9 per cent of carbon. It follows that a pearlite block consists of 13.5 per cent of cementite distributed in the cementite sheets and 86.5 per cent of iron distributed in the iron sheets. This involves the assumption that the

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whole of the carbon found by analysis in the pearlite blocks is used to form cementite and that none of it is in the iron. It is quite possible, however, that there may be a small proportion of the carbon dissolved in the iron sheets. The quantity would be small and would make no material difference to the proportion of iron and cementite composing the sheets of a pearlite block. Assuming that all the carbon present in pearlite is in the cementite sheets, and taking 0.9 per cent as the carbon corresponding to the all pearlite structure, x, the percentage of pearlite in a steel containing c per cent of carbon is

$$x = 111\ c$$

and the iron left over after the pearlite is formed is

$$100 - 111\ c \text{ per cent.}$$

$$100\ fs = fp\ P + fi\ I \quad . \quad . \quad . \quad (1)$$

But $P = 111\ c$ and $I = 100 - 111\ c$.

Substituting these values (1) reduces to

$$fs = 1.11\ c\ (fp - fi) + fi \quad . \quad . \quad (2)$$

Ultimate Strengths.

The strength of pearlite can be found from experiments on steels containing 0.9 per cent of carbon. From experiments which I have made on steels of this composition and with the pearlite structure fully developed I find that "fp" is probably about 62 tons per square inch with the normal manganese, phosphorus, sulphur and silcon. I have found, however, that considerable variation in strength is possible for steel with this carbon content according to its inner structure, i.e., whether or not pearlite has been completely

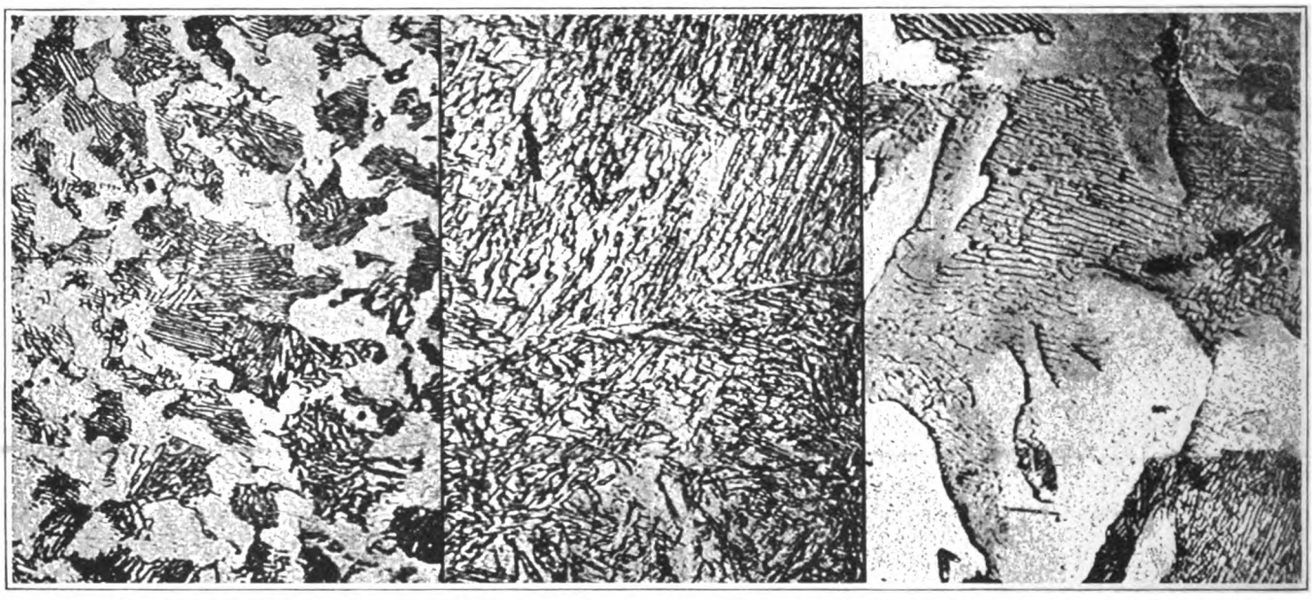

Fig. 12.—Steel, 0.57 carbon, annealed. Magnified 1,000 diameters.

Fig. 13.—Heated to 900 deg. C. and cooled rapidly in water. Magnified 1,000 diameters.

Fig. 14.—Heated to 900 deg. C. and cooled slowly in lime. Magnified 1,000 diameters.

The following table exhibits to the nearest whole number the proportion of iron and pearlite in steel for various percentages of carbon:—

Per Cent Carbon	Per Cent Pearlite	Per Cent Iron	shown in Structure
0.9	100	0	Fig. 5
0.8	89	11	.....
0.7	78	22	.....
0.6	67	33	Fig. 6
0.5	55	45	.....
0.4	44	56	.....
0.3	33	67	Fig. 7
0.2	22	78	.....
0.1	11	89	.....
0.05	5½	94½	.....

The strength of steel depends jointly upon the strength of iron and the strength of pearlite.

If "fp" is the ultimate strength of pearlite, and P is the percentage of pearlite, present, and if "fi" is the ultimate strength of pure iron (ferrite), and I the percentage of iron present, then "f s," the strength of the steel, is—

formed. The curve of the load extension diagram is seen in Fig. 11, preceding page; it is strikingly different from forms of curves for steels with a carbon content up to 0.7 per cent. This difference in form suggests that there is some discontinuity in the properties of the material in the region of this particular mixture—the eutectic mixture, as it is called. This is a point which requires further investigation.

It is more difficult to find a true value of the ultimate strength of pure iron. The commercial pure irons contain small quantities of carbon. Some irons contain as much carbon as the mild steels, but I have never been able to find any pearlite in such irons although they contain carbon in quantities which in steels are sufficient to show pearlite. The carbon seems to exist in iron in a different form from that in which it exists in steel. The difference in the manu-

(Continued on Page 297.)

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PRODUCTION TOPICS

Blast Furnace and Steel Mill Power Plants.

Tabulations submitted to the Engineers' Society of Western Pennsylvania by Richard H. Rice and Sanford A. Moss, at a recent meeting, setting forth cost comparisons of turbo-blowers for blowing and turbo-generators for generating electric power for steel mills from surplus gas on one side, with a plant using gas directly in gas-engine-driven blowers and generators on the other hand, are given in full in the March, 1917, "Proceedings" of the society, recently issued. The data include complete tabulations of the cost of operation of each plant for four blast furnaces.

The authors discuss the centrifugal-compressor blast not only from the point of view of cost, but also from that of effect on the furnace, and call particular attention to its steadiness and easy controllability.

As regards the value of accurate control of the rate of air flow in the case of a blast-furnace compressor, the authors quote the following experience. The measuring device which was relied upon to determine the rate at which the blast was being blown was so located that the indications were inaccurate. This resulted in an inaccurate adjustment of the machine. After a considerable period of operation under these conditions the measuring device was so relocated as to make it more accurate. As a result the quantity of dust is said to have decreased to normal, and the output of the furnace increased.

The authors describe in this connection the governor used on blast-furnace blowers built by the General Electric Company. A recent improvement of this governor consists of a means of adjusting the index on the sliding weight to compensate so that the weight can readily be set to take account of the variations in atmospheric conditions. This device is called a volume director.

In the early days of our experience with centrifugal compressors on blast furnaces there used to occur the so-called "surging," which appeared when the machines were operated at considerably less rates of blowing than those for which they were designed, or when excessive pressures were met with as in case of tightening up of the furnace. This "surging" consists of an alternate forward and backward flow of air with the compressor, and is the result of improper functioning of the discharge vanes owing to the variation of blowing conditions from those for which the vanes were designed. The steps which have been taken to eliminate this "surging" are reasonable proportioning of the machine to the requirements of the furnace, and provision of a by-pass with an automatic valve which in conditions which would ordinarily permit "surging" leads back into the inlet a small quantity of air.

The major part of the paper is devoted to a discussion of comparative costs of the two types of plant, turbine- and gas-engine-driven.

TABLE I.—COMPARATIVE COSTS FOR TYPICAL FOUR-FURNACE PLANTS.

	Gas Engine	Steam Turbine
First Costs.		
Primary washers	$ 131,250	$ 131,250
Secondary washing station	300,000	.....
Gas pipe from boiler house	212,500	.....
Boiler and piping	167,500	609,200
Boiler house	41,250	123,750
Electric station apparatus	3,250,000	745,600
Electric station house	250,000	69,200
Blowers, etc.	1,812,500	726,416
Blowing station house	237,500	69,200
Pumping station, standpipe, conduits	787,500	293,484
	$7,190,000	$2,768,100
Charges, Dollars Per Year.		
Primary gas washers	$ 2,100	$ 2,100
Secondary gas washers	42,000	.....
Boilers	12,000	52,750
Electric station	90,000	68,250
Blowing station	49,500	42,000
Pumping station	6,000	4,000
Running charges, total	$ 201,600	$ 169,100
Fixed charges at 13 per cent	934,500	350,800
Coal	21,652	78,352
Total charges	$1,157,752	$ 607,252

Dust Explosions.

An item dealing with the inflammability and explosion risk in handling carbonaceous dusts, such as pulverized coal, is given in an article on the subject, "Inflammability of Carbonaceous Dusts," appearing in a recent issue of the Journal of Industrial and Engineering Chemistry and written by H. H. Brown.

It has been recognized for some time that many explosions were due to dust, but in the case of mines it is only within the last thirty years that it has been fully recognized that coal dust alone is explosive, even though there be no gas present. Experiments have proven that many other dusts are just as easily ignited and fully as capable of explosion as is coal dust, in fact no mill handling material containing carbon is immune from the possibility of an explosion. The work, therefore, which has been undertaken to determine conditions under which such explosions may occur, in order to know how to avoid them, is of fundamental importance in avoiding life and property losses.

Dusts may be divided in three general classes. They are, first, those which ignite and propagate flame readily from a very small source of heat, as for example, a lighted match; those which are readily ignited but which require a comparatively large source of heat and high temperature for the propagation of flame. Finally, those which are not capable of propagating flame under the ordinary conditions, either because they do not readily form a cloud of dust in the air or because they are contaminated with a large quantity of incombustible materials of which they are composed which do not burn rapidly enough to cause an explosion.

It has been found that in many respects explosions arising from clouds of dust in the air behave very much like gas explosions. Great pressures are developed, the flame runs at a high velocity per second, and some of the dusts ignite at comparatively low temperatures.

Owing to the large number of variables in the problem, it has been difficult to devise an experimental apparatus in which such explosions could be studied under conditions sufficiently constant to make the results obtained at all valuable. Such difficulties as securing uniform clouds of dust, suitable means of igniting the dust, temperature measurement, pressure measurement, method of introducing the dust into the chamber, etc., have been overcome and the way prepared for tests on a larger scale, which will aid in the interpretation of the results obtained in the first experiments. The data thus far obtained indicate that most of the carbonaceous dusts have a higher degree of explosibility than Pittsburgh coal dust and that the dust is more easily ignited.

All dusts composed of carbon-bearing materials have a high degree of explosibility when occurring in a cloud in the air, and, therefore, a dangerous condition exists, not only where such material is in a cloud, but also if in a position where it may readily be thrown into suspension in the air.

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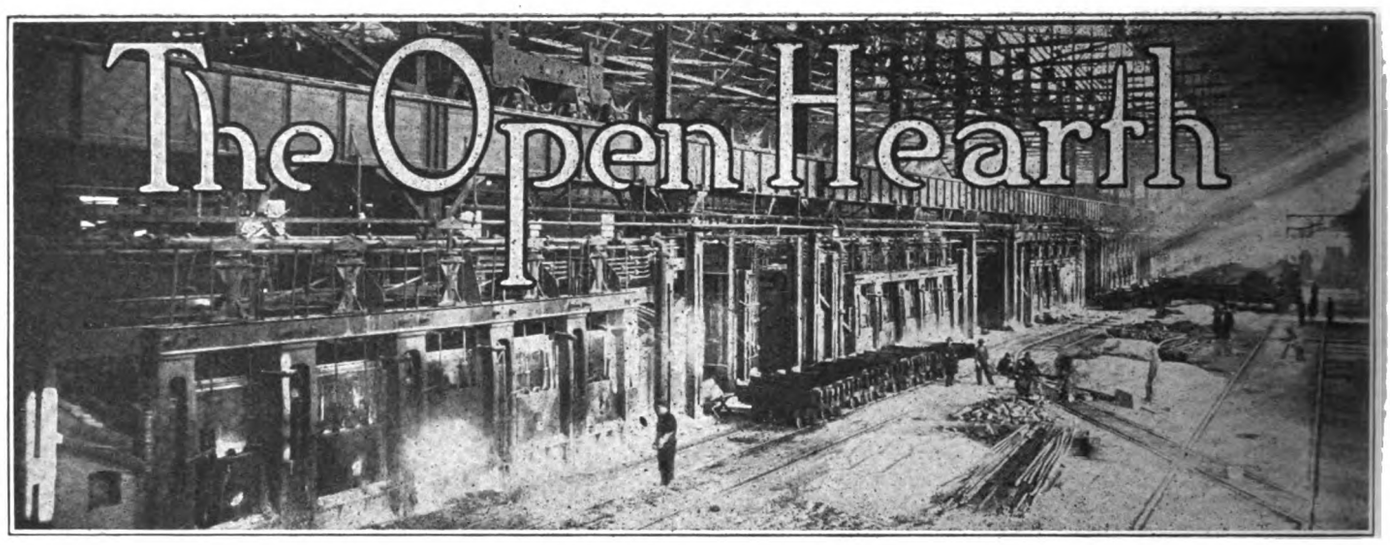

W. D. Jacoway, recently engaged with C. H. MacMillan in the installation and operation of an electric furnace and open hearth plant for the steel department of the Canada Cement Company, has become superintendent of the electric furnace and open hearth departments of Armstrong, Whitworth of Canada, Ltd., Montreal, Que., whose new plant consists of four Heroult and two open hearth furnaces. Mr. Jacoway was formerly in the open hearth department of the Dominion Iron & Steel Co., Sydney, N. S., and more recently with the Bethlehem Steel Company, South Bethlehem, Pa. He was engaged as superintendent of construction of No. 2 open hearth furnace at Lackawanna Steel Co., Lackawanna, N. Y., whence he went to Australia to assist in the construction and operation of open hearth furnaces for the Broken Hill Proprietary Co.,

V V

H. M. Steele, manager of the Guernsey works of the American Sheet & Tin Plate Company. Cambridge, Ohio, has resigned, to become general manager of the newly organized Liberty Steel Company, Warren, Ohio.

V V

At a recent meeting of the Board of the Massey-Harris Company, Ltd., Toronto, Ont., the following officers were elected: Thomas Findlay, President and general manager; Joseph N. Shenstone, First Vice President; C. L. Wisner, Second Vice President and George Valentine, assistant general manager.

V V

D. B. Gallagher, formerly superintendent of the bar mill of the Pittsburgh Crucible Steel Company, has been appointed superintendent of the blooming and billet mills. C. S. Capehart succeeds Mr. Gallagher as superintendent of the bar mill.

V V

J. D. Holcomb, in charge of the reconstruction of the old Diamond State Steel plant at Wilmington, Del., now operated by the Wilmington Steel Company, has resigned. He has been succeeded by F. J. Cort, of Duquesne, Pa.

V V

E. C. Bauer of the sales department of the American Manganese Steel Company, Chicago, has been appointed assistant to the Vice President.

V V

T. F. Webster has resigned as manager of the Pittsburgh office of the Link-Belt Company to become vice president of the R. H. Beaumont Company, 432 Chestnut street, Philadelphia, builders of conveying machinery. He has been succeeded by L. M. Ewell of the Philadelphia office of the Link-Belt Company.

V V

M. D. Whitford has been elected treasurer of the Semet-Solvay Company, Syracuse, N. Y., vice F. R. Hazard, deceased.

V V

P. M. Smith, formerly with The William Tod Company, Youngstown. Ohio, has been appointed chief draftsman of the Standard Engineering Company, Ellwood City, Pa.

V V

Ralph Donaldson has been appointed superintendent of the Bucyrus (O.) plant of the Ohio Steel Foundry Company, vice C. W. Lytle, resigned. The Ohio Steel Foundry Company recently acquired the plant of the Blackwood Steel Foundry Company, Springfield, Ohio.

V V

R. J. S. Pigott of the Remington Arms Union Metallic Cartridge Company. Bridgeport, Conn., has resigned to accept a position with the Sanford-Riley Stoker Company, Ltd., Worcester, Mass.

V V

T. S. Fuller formerly treasurer of the Alberger Pump & Condenser Company, 90 West Street, New York is now treasurer of the Crocker-Wheeler Company, Ampere, N. J.

V V

G. L. Danforth, Jr., open hearth superintendent, South Works of the Illinois Steel Company, South Chicago, has been promoted to the position of superintendent of steel construction.

V V

Samuel Naismith, general mason foreman. Illinois Steel Company, South Chicago, has been promoted to master mason, and will look after the mason work for the mechanical department in addition to his other work.

V V

Charles A. Palgren, formerly assistant foreman of the mechanical department of the Illinois Steel Company South Chicago, and in charge of the experimental tool department is now manager of the Steel Art Tool Company, Chicago, Ill.

V V

O. L Pringle has become assistant to the general manager of the Cambria Steel Company, Johnstown, Pa., a position until recently held by Harry A. Whitaker, who recently was made general superintendent of Worth Brothers' plant of the Midvale Steel and Ordnance Company, Coatesville.

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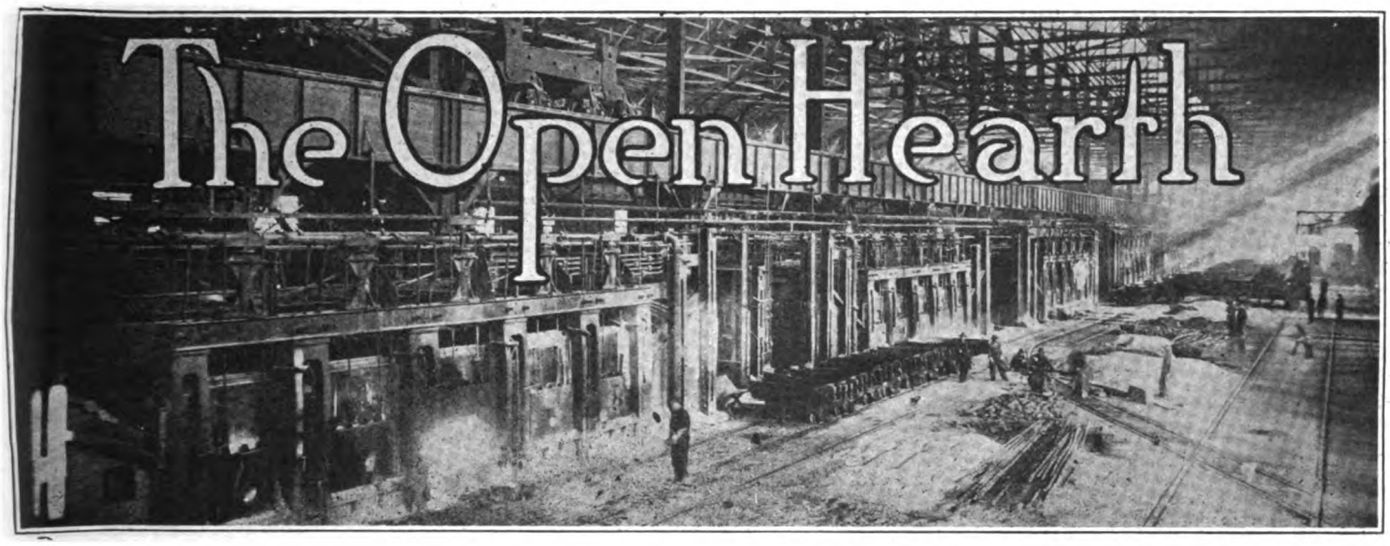

John E. Perry, assistant to the president of the Brier Hill Steel Company, Youngstown, has been elected president of the Wharton Steel Company, Wharton, N. J., effective June 1. Mr. Perry had held the Brier Hill position only a few weeks. His work has dealt mainly with coal and transportation of raw materials. He was formerly with the Republic Iron & Steel Co., with which he had held a similar position. Mr. Perry will direct the reopening of the Wharton company's ore mines in New Jersey. H. S. Endsley, who was temporary president of the company, will continue as general counsel.

V V

Lee H. Mandeville, formerly chief electrician with the United Furnace Company of Canton, O., has gone to the National Pressed Steel Company, of Massillon, O., as electrical engineer.

V V

Norman L. Baker has taken a position as chief engineer at the East St. Louis (Ill.) plant of the American Steel Foundries, and not as works manager, as erroniously stated in this department a month ago. The position of works manager at the East St. Louis plant continues to be filled by P. J. Ward.

V V

R. D. Nye has been appointed electrical engineer with the United Alloy Steel Corporation. Canton, O. The same company has named H. H. Pleasance manager of sales. E. D. Rogers, who has been vice president and manager of sales, will continue as vice president of the company. Mr. Pleasance has been assistant manager of sales for a number of years.

V V

John D. Hurley, vice president of the Independent Pneumatic Tool Co., Chicago, has been elected president to succeed the late James Buchanan Brady. Ralph S. Cooper, manager of the New York office of the company, has been made vice president to succeed Mr. Hurley and Robert T. Scott, manager of the Pittsburgh branch has been elected a director and member of the executive board.

V V

A. N. Diehl has been appointed assistant to William Whigham, vice president of the Carnegie Steel Co., with offices at Pittsburgh. S. G. Worton, formerly superintendent of the open hearth department at the Duquesne works of the company, has succeeded Mr. Diehl as assistant general superintendent of the Duquesne plant. R. B. Bostwick has succeeded Mr. Worton. F. W. Underwood has been appointed superintendent of river transportation of the Carnegie Company.

V V

Charles C. Lynde, engineering editor of THE BLAST FURNACE AND STEEL PLANT, joined the engineer officers' reserve camp at Ft. Oglethorpe, Ga., on May 21.

V V

At the Annual Meeting of the American Iron and Steel Institute on May 7, the following directors were re-elected for the three-year term ending in 1920: L. E. Block, A. C. Dinkey, James A. Farrell, Elbert H. Gary, Robert Hobson, Charles M. Schwab, Powell Stackhouse. The following condidates for membership were elected to the waiting list:

E. Austin Barnes and Eugene A. King, mechanical engineers, Semet-Solvay Company, Syracuse, N. Y.; Fred R. Drake, vice president, Thomas Iron Company, Easton, Pa.; Charles V. McIntire, chief engineer, Otto Coking Company, 6 Church Street, New York City; John Woodman Higgins, president and treasurer, Worcester Pressed Steel Company. Worcester. Mass.; Frank B. Baird, president, Charles Augustus Collins, second vice president and Harry Yates, vice president and treasurer, Buffalo Union Furnace Company, Buffalo, N. Y.; Harry Halsey Cook, sales manager, Titanium Alloy Manufacturing Company, Niagara Falls, N. Y.; Robert N. Keeney, open hearth superintendent, Atlantic Steel Company, Atlanta, Ga.; James C. Rea, manager of factories. Oliver Iron and Steel Company, Pittsburgh; Walther Mathesius, superintendent blast furnaces, Illinois Steel Company, South Chicago.

V V

At a meeting of the Board of Directors of the Walter A. Zelnicker Supply Company, St. Louis, held April 19, A. R. Topping was elected Secretary of the company.

V V

Farrar & Trefts, Inc., Buffalo, N. Y., announce the appointment of Henry F. Russell, formerly with the Lumen Bearing Company, as sales manager of their grey iron department.

V V

William H. Stevens, of Bellaire, O., has been made furnace superintendent of the Leetonia (O.) plant of the McKeefrey Iron Company.

V V

Arthur W. Lyle, formerly superintendent of blooming, billet and skelp mills at the Aliquippa (Pa.) plant of the Jones & Laughlin Steel Company, has severed that connection to becoming superintendent of blooming mill and rod mills at the Peoria (Ill.) plant of the Keystone Steel & Wire Company.

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CO-OPERATION AND THE MOBILIZATION OF PUBLIC SENTIMENT.*

(Continued from Page 273.)

able to the protection of general business that it is freely predicted she will abandon in the near future her traditional policy of free trade. England has also closely followed Germany in the policy of encouraging capital combinations for trade, even to the extent of assisting such combinations by Government loans, where necessary, thus recognizing that it requires big business to develop national resources or to promote and maintain industry successfully. The dye-stuff trade is a notable case of this character. While coöperation as practiced by the various governments now engaged in war, may be, as claimed by some writers, a "real working of state socialism," I maintain that it is at least enlightened socialism, for through the application of German and English business methods waste is minimized, efficiency stimulated and productivity increased. Germany not only proposes to continue her past coöperative methods, but also proposes to extend her syndicate operations in the future beyond a mere control of sales, her war experience showing that purchases can also be syndicated to advantage, and furthermore, that capital investment when regulated will avoid unnecessary duplication of plants and thus prevent wasteful competition. I am convinced that we also must adopt, as a national system, coöperation as practiced abroad; also enter into reciprocal tariffs: and, furthermore, we must coöperate wherever possible, not only at home, but also with all foreign countries who are reciprocally inclined.

Legislation for Peace Times.

The mobilization of public sentiment by educational processes, however, takes time and we should not delay our efforts to "Wake up America" to the problems of peace and to emphasize the necessity for co-operation. To make this accomplishment practical and possible, constructive legislation of somewhat the following character will be necessary:

First.—Amendments to the Sherman Anti-Trust Act to legalize price coöperation, and subject possibly to government regulation, to become effective after the war, so as to prevent disorderly liquidation of commodity values during the reconstruction period, and to stabilize values thereafter for the protection of the general public.

Second.—Revision upwards of the tariff where necessary to protect home trade against unfair foreign competition; preferential tariff rates, however, to obtain wherever reciprocal trade agreements can be made to our advantage.

Third.—A thorough overhauling of our Marine Laws and the enactment of such amendments as will justify and encourage capital to become interested permanently in the operation of over-seas shipping. If proper protection cannot be given capital to justify it engaging in over-seas shipping and to successfully compete with foreign ships without subsidy, then we should subsidize American shipping.

The method I would suggest for promoting the necessary preliminary campaign of education for the mobilization of public sentiment favorable to this legislative program would be coöperative publicity.

I am thoroughly convinced that no executive or business man, particularly those who are directing the affairs of public corporations, will hereafter fully measure up to their executive or public responsibilities who does not give these questions his most careful thought, and who is not also willing to devote at least part of his time to public service. In a recent discussion of this subject that I had with a prominent Senator, he admitted that one of the great difficulties confronting the nation is that real politics and real business are not well acquainted; that neither fully understands the principles or the motive-power that is driving the other side. * * * * Even Washington, as has been recently remarked, now recognizes the value of coöperation and of a "Gary dinner" when it is desirable to mark prices down.

Immediate Steps.

I would therefore urge upon all of you to "speak, act and serve together" in the work of mobilizing public sentiment for coöperation, for the prevention of waste, for the conservation of our natural resources, for the encouragement of thrift, and for the general prromotion of the public welfare. Let me also urge upon you to enlist for this service now; begin your campaign at home, educate your local Chamber of Commerce to our business needs, urge the coöperation of your local press, and also endeavor to educate your employes, as some employers now do, by the distribution of leaflets on pertinent subjects through the pay envelope, or by the distribution of other literature, to the viewpoint that your interest is their interest. Furthermore, we should impress upon our representatives both in House and Senate that their coöperation in this general welfare work will hereafter be considered by their constituency as part of their official obligation. As a preliminary step towards educating the employe of foreign birth in the fundamentals of citizenship, we should also give more active support to the Americanization movement by coöperating with the Y. M. C. A. and our local Boards of Education. As evidence of the practical character of this coöperative work, the Youngstown, Ohio, Americanization Committee reports that 144 foreigners, representing 16 different nationalities, were graduated during May into full citizenship after passing all the educational tests required.

As both "big and little business" are loyally supporting the government in times of war, "big and little business" should demand loyal support by the government in times of peace.

BEEHIVE OVEN BUIILDING AT LOW EBB.

The production of beehive coke in 1916 was the greatest ever recorded in the United States, and the average value per ton was higher than in any previous year. The official figures for 1916, just published by the United States Geological Survey, Department of the Interior, show that 35,464,224 tons of beehive coke, valued at $95,468,127, were produced last year, an amount differing by less than 1 per cent from the preliminary estimates of C. E. Lesher, of the Geological Survey, published on January 1, 1917. The output in 1916 represented an increase over 1915 of 7,655,969 tons, or 29 per cent, in quantity, and $38,522,584, or nearly 68 per cent, in value. The average value per ton of the coal used in making beehive coke in 1916 was $1.26, an increase of 21 cents, or 20 per cent, and the average value of the coke was $2.69, an increase of 62 cents, or 30 per cent.

The number of active beehive ovens in 1916 was 65,605 as against 48,985 in 1915, an increase of 16,620. The number of idle ovens was 25,976, as against 44,125 in 1915. Abandoned ovens numbered 2,265, of which nearly 1,800 were in Pennsylvania and West Virginia. No new establishments and but 104 new beehive ovens at old works were reported to be under construction at the end of 1916, a low record compared with recent years, especially in view of the high prices and steady demand for coke throughout the year. The coke producers evidently recognize the fact that the day of the beehive oven is passing and that after the present abnormal condition is over most coke will be made in by-product ovens. The official figures showing the production of coke in by-product ovens in 1916 have not yet been compiled.

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NEWS OF THE PLANTS

STEEL TONNAGE FOR 1913.

The American Iron & Steel Institut's report on production of steel and rolled steel products for the year 1916 was issued on May 24. It shows the total steel output for the year to have been 42,773,680 tons, or more than 10,000,000 tons in excess of the 1915 total. Of this, 41,401,917 tons were ingots and 1,371,763 tons were castings. In ingots and castings combined, the totals were, by grades, as follows, in three years:

PROCESS.	YEARS 1913	1914	1915	1916
Basic, O. H.	20,344,626	16,271,129	22,308,725	29,616,658
Acid, O. H.	1,255,305	903,555	1,370,377	1,798,769
Bessemer	9,545,706	6,220,846	8,287,213	11,059,039
Crucible	121,226	89,809	113,782	120,092
Electric	30,180	24,009	69,412	168,918
Miscellaneous	3,831	3,622	1,527	604
Total	31,300,874	23,513,030	32,151,036	42,773,680

Included in the 29,616,658 tons of basic open-hearth steel ingots and castings produced in 1916 are 3,436,457 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 1,781,491 tons in 1915, an increase of 1,654,966 tons, or 92.9 per cent. In 1914, the production was 835,690 tons and in 1913, 2,210,718 tons. The alloy steel output was:

	Ingots	Castings	Total
Year 1913	625,430	88,927	714,357
Year 1914	577,107	69,846	646,953
Year 1915	923,251	97,896	1,021,147
Year 1916	1,306,157	56,458	1,362,615

Rolled iron and steel in all forms (including blooms, billets and axle blanks rolled for forging purposes and semi-finished products rolled for export) showed an increase of 32.7 per cent over 1915. The totals are as follows:

PRODUCTS.	YEARS 1913	1914	1915	1916
Iron and steel rails	3,502,780	1,945,095	2,204,203	2,854,518
Plates and sheets	5,751,037	4,719,246	6,077,694	7,453,980
Nail plate	37,503	38,573	31,929	30,088
Wire rods	2,464,807	2,431,714	3,095,907	3,518,746
Structural	3,004,972	2,031,124	2,437,003	3,029,964
All other rolled	10,030,144	7,204,444	10,546,188	15,493,093
Total	24,791,243	18,370,196	24,392,924	32,380,389

In all divisions shown above, the 1916 totals are new high marks, with the exception of rails. The rail tonnage of 1916 was exceeded in ten previous annual totals—namely, those for 1901, 1902, 1903, 1905, 1906, 1907, 1909, 1910, 1912, and 1913. The following table itemizes finished product outputs for 1916, specifying iron and steel:

Products.	Iron	Steel	Total
Rails	.....	2,854,518	2,854,518
Plates and sheets	13,303	7,440,677	7,453,980
Nail and spike plate	2,979	27,109	30,088
Wire rods	867	3,517,879	3,518,746
Structural shapes	1,823	3,028,141	3,029,964
Merchant bars	993,948	5,625,598	6,619,546
Bars for relining concrete work	2,683	458,717	461,400
Skelp, flue, and pipe iron or steel	355,445	2,572,229	2,927,674
Long angle splice bars, tie-plate bars, etc.	77,656	614,164	691,820
Hoops	630	367,534	368,164
Bands and cotton-ties	.....	173,311	173,311
Rolled sheet piling, not including fabricated	.....	19,196	19,196
Railroad ties	.....	34,311	34,311
Rolled forging blooms, forging billets, etc.	549	2,015,411	2,015,960
Exports of blooms, billets, sheet bars, etc.	.....	512,483	512,483
All other finished rolled products	372,688	1,296,540	1,669,228
Total, gross tons	1,822,571	30,557,818	32,380,389

To the 19,196 tons of rolled steel piling reported above should be added 4,848 tons of fabricated sheet piling produced during the year. The report on production of finished rolled forms by States shows that, of the total production in 1916, 47.65 per cent was rolled in Pennsylvania, as compared with 49.17 per cent in 1915; and in 1916, 18.05 per cent was rolled in Ohio, as compared with 19.41 per cent in the previous year.

Statistics on production of plates are itemized as follows:

Kinds.	YEARS 1915	1916
Universal plates	954,852	1,224,234
Sheared plates—		
Rolled on single stands	1,626,559	1,982,863
Roughed and finished on separate stands	296,640	470,287
Black sheets made on sheet or job mills	1,836,786	2,249,597
Black plates, including black plates for tinning and black plate specialties rolled on tin mills	1,362,857	1,526,999
Total	6,077,694	7,453,980

Classified by size and mode of manufacture, the production of plates and sheets shows the following totals:

Kinds of products.	Iron	Steel	Total
Universal plates, inc. flats or bars over 6 in. wide:			
¼ of an inch and over in thickness	4,013	1,166,952	1,170,965
Under ¼ of an inch thick	2	53,267	53,269
Total universal plates	4,015	1,220,219	1,224,234
Sheared plates:			
¼ of an inch and over in thickness	1,142	1,864,500	1,865,642
Under ¼ of an inch thick	321	587,187	587,508
Total sheared plates	1,463	2,451,687	2,453,150
Black sheets, made on either sheet or job mills:			
No. 12 gauge and thicker	29	271,780	271,809
No. 13 gauge and thinner	5,918	1,971,870	1,977,788
Total black sheets	5,947	2,243,650	2,249,597
Black plates rolled on tin mills:			
Black plates for tinning	1,878	1,281,924	1,283,802
Other black plate specialties	.....	243,197	243,197
Total black plates rolled on tin mills	1,878	1,525,121	1,526,999
Grand total of plates and sheets	13,303	7,440,677	7,453,980

By widths, the tonnage of universal plates is divided as follows:

Width of universal plates	Iron	Steel	Total
Under 30 inches wide	4,015	952,571	956,586
30 inches wide, but under 48 inches wide	.....	247,545	247,545
48 inches wide and over	.....	20,103	20,103
Total	4,015	1,220,219	1,224,234

CONTRACTS FOR NEW WORK.

A new steel works is being built at St. Francis, Wis., a few miles south of Milwaukee, by the Valley Steel Company, recently organized. The first unit will consist of two 80-ton open hearth furnaces, three 10-ton and one 1½-ton electric furnace, foundations for which have been laid. W. E. Moore & Company, consulting engineers, Pittsburgh, who have charge of the construction of the plant, have designed a 24-inch billet mill and a 104-inch plate mill. A contract for a 10-inch merchant bar mill has been awarded to the United Engineering & Foundry Company, Pittsburgh.

MANUFACTURERS' PUBLICATIONS.

Tht Link-Belt Company has issued, as Booklet 253, under the title, "The Ideal Drive for Cement Mills," a description of a large Link Belt silent chain drive installation at the plant of the Nazareth Cement Company at Nazareth, Pa. Other Link-Belt booklets received are:

Traveling Water Screens for Condenser Intake, No. 305,
Blue Diamond Coal Company Tipple, No. 308,
Increasing Profit by Saving Expense in the Handling and Storing of Coal and Ashes, No. 304,
Some Modern Coal Tipples, No. 303.
Link-Belt Silent Chain Data Book No. 125, 1917 edition.

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This is the only work of its kind ever published and seems likely to enjoy a wide popularity.

Wagon and truck loader catalog, No. 270.

The Smith Gas Engineering Company, Lexington, O., has issued an elaborately illustrated catalog, showing Smith Type "MB" gas producer plants delivering cold, clean gas from bituminous coal. Analyses and charts containing much new data, and illustrations of existing installations are features of the publication.

Cutler-Hammer, of Milwaukee, have issued Booklet "E," describing C-H Control Equipment for Electric Elevators. This booklet covers the various classes of control, such as. Hand Rope Control, Car Switch Control, Push Button Control, for all classes of freight and passenger service.

Tate-Jones & Company, Inc., Pittsburgh, have issued a new edition of their booklet "Heat Treating of Steel," bringing much operating data up to date. New formulae and changes in existing methods are given in compact and convenient form.

The American Steel Export Company, Woolworth building, New York, has issued a booklet entitled, "Export Engineering and Contracting," which deals with its organizaation and service and contains valuable rules for export shipments.

SAFETY NOTES.

The new emergency hospital of the LaBelle Iron Works has been opened at Wheeling, W. Va. Dr. Curtis Laughlin is in charge of this unit.

The record for this much of 1917 at the South Works of the Illinois Steel Company, South Chicago, Ill., shows a reduction of 48 per cent in accidents as compared with the record for 1916.

REMOVAL OF OFFICES.

The Pittsburgh Steel Company, Pittsburgh, has removed its offices from the Frick building to the Union Arcade building.

The Draeger Oxygen Apparatus Company, formerly located at 422 First avenue, Pittsburgh, has removed its plant and offices to the Boyd building, Hay street and Sawyer way. Wilkinsburg, Pa.

TRADE ORGANIZATIONS.

The American Board of Scrap Iron Dealers organized at an informal meeting held in the Ft. Pitt hotel, Pittsburg, on May 15, with the following officers:—President, W. J. Shroder, Cincinnati; secretary and treasurer, C. A. Barnes, Philadelphia; executive committee, Eli Joseph, New York; Joseph Michaels, Charles Dreifus, Pittsburgh; Vernon Phillips, Boston; A. J. Bialsky and Harry Grant.

Pittsburgh Section, American Institute of Electrical Engineers, at its June meeting, at the Monongahela house, Pittsburgh, on June 16, will hear a paper on "By-Product Coke Ovens in the Steel Industry," by James Farrington. There have been quite a number of By-Product Coke Oven Installations in the various steel plants in the vicinity of Pittsburgh, which will be touched on in the paper.

The United States Geological Survey, Department of the Interior, has just published a report on the zinc resources of each zinc-producing State in the United States, accompanied by a map showing the location of zinc-producing districts, zinc smelters, electrolytic zinc plants, and zinc oxide plants, and by tables showing the priduction fir several years. A copy of this report, which was prepared by C. E. Siebenthal, may be obtained by addressing the Director, U. S. Geological Survey, Washington, D. C.

RECENT PATENTS

The following patents are reported expressly for The Blast Furnace and Steel Plant, by E. G. Siggers, patent attorney, Suite No. 31, National Union building, Washington, D. C., from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps:

William A. Darrah and Samuel Trood, of Wilkinsburg, Pa., have invented improvements in vapor treatment of metals, No. 1,224,339, dated May 1, 1917. The invention relates to methods of treating metals by the introduction of other substances into them. It is frequently desirable to change the qualities of a metal by the addition of other metals or other substances, and it may be expedient for reasons of cost, or otherwise to effect this addition after the metal is brought into the final form: in other words, under conditions such that a surface alloy or compound is preferable to a homogeneous metal. The invention, therefore comprises a method of forming a surface compound or alloy which possesses the desired properties. Thus we may treat iron so that the outer layer will be rust proof; we may treat copper or iron, etc., so that its outer layer will be extremely hard or extremely tough, or resist certain agents, etc.

Samuel Trood, of New Castle, Pa., assignor to Industrial Development Company, a corporation of Pennsylvania, has invented improvements in a machine for continuous treatment of metals, No. 1,224,340, dated May 1, 1917. The invention relates to the coating of metals with a protecting layer and more directly to the process of forming a metallic or other coating, by the vapor process, and provides a device for continuously subjecting a new supply of metal to the treating conditions and removing the portion of metal already treated.

August S. Lind, of McKeesport, Pa., has invented improvements in an apparatus for polishing rolling mill rolls, No. 1,224,389, dated May 1, 1917. The invention relates to an improved apparatus for polishing rolling mill rolls and it comprises a series of removable polishing blocks, held in contact with said rolls by means of spring-actuated holders, arranged in oblique positions, the one overlapping the other, a means for placing a pressure upon said blocks, and a means of maintaining said pressure; together with the certain details of construction and combination of parts, as will be fully described hereinafter. In the present practice and method of rolling "tin plate," and also all sheet metals, it is necessary to "close the mill" at certain intervals, in order that the rolls may be polished, for reasons well known in the art. This necessitates a considerable delay, resulting in the loss of time, expense, trouble and increased cost of the product. The object of this invention is to place a permanent polishing apparatus in connection with each set of rolls, that will continuously polish said rolls while the same are in operation, without interfering with the workmen or product of the mill.

Frank D. Carney and Lewis B. Lindemuth, of Bethlehem, Pa., have invented improvements in manufacture of steel, No. 1,223,030, dated April 17, 1917. This invention relates to the manufacture of steel by the duplex process, namely, where the pig iron is first treated in a Bessemer converter, and then treated under basic conditions in a basic lined open hearth, or equivalent, furnace for further purification. The steel is then run into ingot molds, and the ingots suitably treated and manufactured into commercial rolled shapes. The method comprises charging Bessemerized metal into a basic open hearth furnace with sufficient manganese bearing material to produce a slag under basic conditions whose manganese content is sufficiently great to permit a reduction of a portion of said manganese content and cause its entrance into and its retention in the metal of the bath beneath it.

James C. Davis, of Hinsdale, Ill., has invented improvements in apparatus for handling molten steel, No. 1,223,479, dated April 24, 1917, and he has assigned the same to American Steel Foundries, of New York, N. Y., a corporation of New Jersey. This invention relates to the art of producing steel and has particular reference to a novel ladle for use in connection therewith. The ladle is provided with a plurality of openings in its side wall near its upper end, said openings being spaced apart vertically and means for plugging said openings.

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Strength and Inner Structure of Mild Steel

(Continued from Page 282.)

facturing processes may account for this, because it must not be forgotten that iron is produced by processes which do not involve the melting of the iron at any stage. On the other hand, steel is made from a re-melt of the pig-iron produced in the blast furnace, and carbon is added to it in the bath in the form of ferro-manganese. Sir Robert Hadfield gave me some very pure Swedish iron containing only 0.04 per cent of carbon, and the average of six tests on this material gave an ultimate strength of 18.8 tons per square inch. From the diagram immediately to be described, it is deduced from this and other data that the ultimate strength of pure iron is about 16 tons per square inch.

The ultimate strengths of a series of steels are plotted against their respective pearlite contents in Fig. 9. The scale of carbon content is added below the pearlite scale. Point 1 is the ultimate strength of good Swedish iron containing 0.04 per cent of carbon. Point 2 corresponds to a steel containing 0.9 per cent of carbon, and its structure is shown in Fig. 3. The line joining points 1 and 2 cuts the vertical axis through the origin at 16, indicating that the ultimate strength of carbon free iron which has been worked is probably about 16 tons per square inch. The ultimate strength of the 0.57 carbon steel shown in Fig. 6 is plotted in point 3, and point 4 corresponds to the structure shown in Fig. 7. Other points are plotted on the diagram showing the results of tests made on annealed steels of known carbon contents. Variations of ultimate strength from any linear law are to be expected owing to the effects of the various impurities Mn, Si, S and P, but the nearness of the points to the line suggests that the line fairly represents the strength of steel in terms of the pearlite content at any rate to a first approximation.

Introducing the values therefore—

$$fi = 16 \text{ tons per square inch}$$
$$fp = 62 \text{ tons per square inch.}$$

equation (2) above becomes—

$$fs = 1.11\ c\ (62 - 16) + 16 = 51\ c + 16 \qquad (3)$$

This relation therefore represents the ultimate strength of good commercial steel of normal quality after annealing to allow the pearlite to form. Overstrained steels or steels containing excess of any of the ordinary impurities would show departures from the general law.

Characteristic Curves.

Fig. 10, is a facsimile of the diagram corresponding to point 5, Fig., 9, and shows well the characteristic curve for steel, namely, an elastic part joined to a plastic part by an irregular link beginning with a definite drop from the breaking-down load.

A selected number of these load-extension diagrams have been reduced to a common scale of ultimate stress and elongation for the sake of comparison and are plotted over one another in Fig. 11. The progressive decrease of ductility with increase of strength brought about by increasing proportions of pearlite in the structure is well exhibited by these curves.

Figs. 12, 13, 14, show the different inner structures of a piece of the same steel brought about by different rates of cooling. The steel sample, the structure of which is seen in Fig. 12, was heated to 900 deg. C. and quenched rapidly in water; the resulting structure is seen in Fig. 13. It was then heated again to 900 deg. C. and cooled slowly; the original pearlite structure was recovered, as will be seen in Fig. 14. The original pearlite structure seen in Fig. 12 is finer in texture and the pearlite blocks are smaller than in the recovered pearlite structure seen in Fig. 14. The structure Fig. 12 was formed in the bar before the small cube, which was afterwards polished and etched, was cut off. The annealed structure Fig. 14 was produced by heating and slowly cooling this small cube. The circumstances of the formation of the two structures were therefore different both as regards the internal pressures produced by cooling and the configuration and slope of the lines of heat flow.

Structural Changes in Pig Iron.

As mentioned above, the pearlite structure of pig iron shown in Fig. 8, is not the only structure in the metal. As the field of view is changed other structures of remarkable beauty appear. A general view of a polished and etched surface of a piece of Cleveland mottled pig-iron, under the moderate magnification of 62 diameters, is shown in Fig. 4, and seen in the microscope reminds one irresistibly of mountain scenery. The crystal network is a mixture of iron-carbon and phosphorus in the most fusible proportion. Fig. 5, seen in connection with Fig. 4, shows an area of this general figure on an enlarged scale. Pearlite structures are here seen.

These structures are not all formed at one temperature as the metal cools neither are they dissolved into liquid iron at one temperature. A remarkable series of changes takes place in the solid before the metal is actually melted. Imagine that a piece of the metal can be placed in a crucible in circumstances which enable its inner structure to be projected as a picture on a screen so that we can look at the picture during the process of heating and liquefaction. The first picture on the screen would be like Fig. 4, and this would remain until the temperature reached about 725 deg. C., when the pearlite would fade away. The sheets of cementite would, though solid, dissolve into the sheets of solid iron and produce a homogeneous mixture of cementite and iron; the mixture called austenite. The geography of the picture would remain the same, but from this point onwards the cemetite crystals (seen clearly in Fig. 4) round about the gray masses of austenite would in part be absorbed into them, because iron is able to dissolve increasing quantities of cementite as the temperature rises. At about 953 deg. C. the iron-phosphorus-carbon mixture (seen plainly in Fig. 5,) would melt and the temperature rising there would be pockets of liquid material distributed through the still solid mass of austenite and cementite crystals. At about 1,100 deg. C. the cement crystals would melt and the austenite would begin to melt, and would go on melting with rising temperature until the mass was wholly liquid.

Evolution During Cooling.

If now the temperature were allowed to fall again the operations would take place in the reverse order. First crystals of the solution of iron and cementite would grow in the fir-tree form, and not until the temperature had fallen to about 1,100 deg. C. would the cementite begin to form crystals on its own account. The cooling mass would then appear as a conglomerate of fir-tree blocks or crystallites, the crystal elements of which are formed of a solution of cementite in iron austenite, and separate crystals of pure cementite, and these would by now be solid; but distributed through the solid mass would be liquid pockets of the iron-phosphorus-carbon mixture about to form the crystal net-like structure when the temperature has fallen to 953 deg. C. The picture would now show a mass completely solid; but probably much change in the geography would be noticed as the mass colled, because the cool structure exhibits the crushed and distorted remains of the fir-tree crystallites, and they appear to have been subject to great pressure during the cooling process. A cursory examination of the enlarged photograph in Fig. 5 will show how the regular growth which is indicated by the remains of an uncrushed crystallite enmeshed in crystals of cementite is distorted in the dark areas into blocks of irregular form. Finally at 725 deg. C. we may assume that the geography has settled down to its final shape, and then, given time and patience, all the dark areas would be seen to change into the laminated structure of pearlite.

Each one of these changes is accompanied by heat evolution, and it is this heat evolution which enables the changes to be traced. The process of identifying changes of structure with heat evolution is a laborious one, as will be understood from the Reports of the Alloys Research Committee of the Institution of Mechanical Engineers, reports which are no doubt familiar in a general way to most of us. Professor Carpenter has made extensive researches into the matter, particularly in relation to iron and steel, and has obtained data for the construction of the temperature concentration diagram for carbon in iron. This diagram is exceedingly useful to us as users of steel, and furnishes a key to many apparently disconnected workship processes which have been derived from experience, and which have been tested by experience but are none the less founded on and connected by underlying bonds of pure science. Professor Carpenter has kindly promised to give us a paper next year on the diagram which his own researches have done so much to establish.

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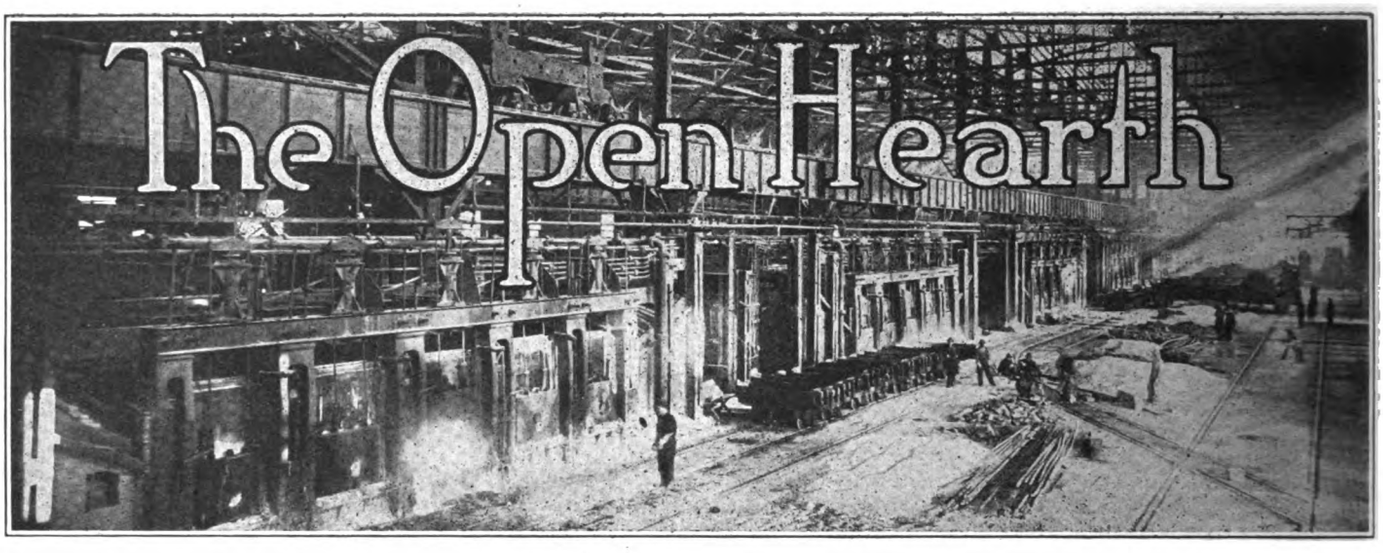

W. D. Jacoway, recently engaged with C. H. MacMillan in the installation and operation of an electric furnace and open hearth plant for the steel department of the Canada Cement Company, has become superintendent of the electric furnace and open hearth departments of Armstrong, Whitworth of Canada, Ltd., Montreal, Que., whose new plant consists of four Heroult and two open hearth furnaces. Mr. Jacoway was formerly in the open hearth department of the Dominion Iron & Steel Co., Sydney, N. S., and more recently with the Bethlehem Steel Company, South Bethlehem, Pa. He was engaged as superintendent of construction of No. 2 open hearth furnace at Lackawanna Steel Co., Lackawanna, N. Y., whence he went to Australia to assist in the construction and operation of open hearth furnaces for the Broken Hill Proprietary Co.,

V V

H. M. Steele, manager of the Guernsey works of the American Sheet & Tin Plate Company. Cambridge, Ohio, has resigned, to become general manager of the newly organized Liberty Steel Company, Warren, Ohio.

V V

At a recent meeting of the Board of the Massey-Harris Company, Ltd., Toronto, Ont., the following officers were elected: Thomas Findlay, President and general manager; Joseph N. Shenstone, First Vice President; C. L. Wisner, Second Vice President and George Valentine, assistant general manager.

V V

D. B. Gallagher, formerly superintendent of the bar mill of the Pittsburgh Crucible Steel Company, has been appointed superintendent of the blooming and billet mills. C. S. Capehart succeeds Mr. Gallagher as superintendent of the bar mill.

V V

J. D. Holcomb, in charge of the reconstruction of the old Diamond State Steel plant at Wilmington, Del., now operated by the Wilmington Steel Company, has resigned. He has been succeeded by F. J. Cort, of Duquesne, Pa.

V V

E. C. Bauer of the sales department of the American Manganese Steel Company, Chicago, has been appointed assistant to the Vice President.

V V

T. F. Webster has resigned as manager of the Pittsburgh office of the Link-Belt Company to become vice president of the R. H. Beaumont Company, 432 Chestnut street, Philadelphia, builders of conveying machinery. He has been succeeded by L. M. Ewell of the Philadelphia office of the Link-Belt Company.

V V

M. D. Whitford has been elected treasurer of the Semet-Solvay Company, Syracuse, N. Y., vice F. R. Hazard, deceased.

V V

P. M. Smith, formerly with The William Tod Company, Youngstown. Ohio, has been appointed chief draftsman of the Standard Engineering Company, Ellwood City, Pa.

V V

Ralph Donaldson has been appointed superintendent of the Bucyrus (O.) plant of the Ohio Steel Foundry Company, vice C. W. Lytle, resigned. The Ohio Steel Foundry Company recently acquired the plant of the Blackwood Steel Foundry Company, Springfield, Ohio.

V V

R. J. S. Pigott of the Remington Arms Union Metallic Cartridge Company. Bridgeport, Conn., has resigned to accept a position with the Sanford-Riley Stoker Company, Ltd., Worcester, Mass.

V V

T. S. Fuller formerly treasurer of the Alberger Pump & Condenser Company, 90 West Street, New York is now treasurer of the Crocker-Wheeler Company, Ampere, N. J.

V V

G. L. Danforth, Jr., open hearth superintendent, South Works of the Illinois Steel Company, South Chicago, has been promoted to the position of superintendent of steel construction.

V V

Samuel Naismith, general mason foreman. Illinois Steel Company, South Chicago, has been promoted to master mason, and will look after the mason work for the mechanical department in addition to his other work.

V V

Charles A. Palgren, formerly assistant foreman of the mechanical department of the Illinois Steel Company South Chicago, and in charge of the experimental tool department is now manager of the Steel Art Tool Company, Chicago, Ill.

V V

O. L. Pringle has become assistant to the general manager of the Cambria Steel Company, Johnstown, Pa., a position until recently held by Harry A. Whitaker, who recently was made general superintendent of Worth Brothers' plant of the Midvale Steel and Ordnance Company, Coatesville.

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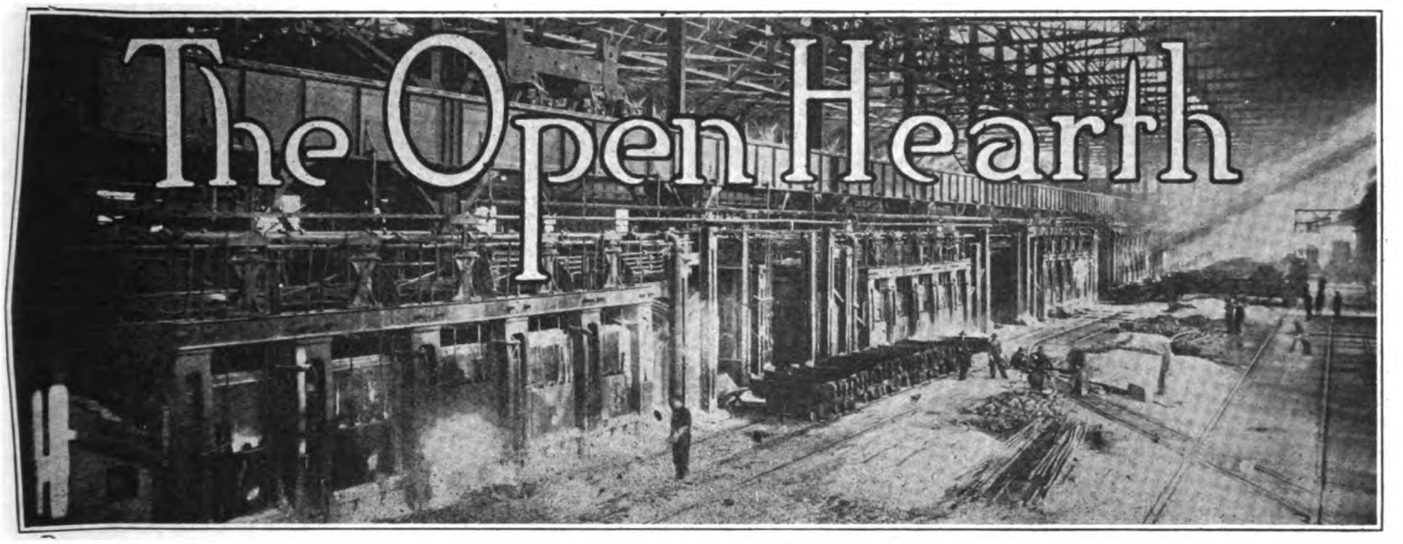

John E. Perry, assistant to the president of the Brier Hill Steel Company, Youngstown, has been elected president of the Wharton Steel Company, Wharton, N. J., effective June 1. Mr. Perry had held the Brier Hill position only a few weeks. His work has dealt mainly with coal and transportation of raw materials. He was formerly with the Republic Iron & Steel Co., with which he had held a similar position. Mr. Perry will direct the reopening of the Wharton company's ore mines in New Jersey. H. S. Endsley, who was temporary president of the company, will continue as general counsel.

V V

Lee H. Mandeville, formerly chief electrician with the United Furnace Company of Canton, O., has gone to the National Pressed Steel Company, of Massillon, O., as electrical engineer.

V V

Norman L. Baker has taken a position as chief engineer at the East St. Louis (Ill.) plant of the American Steel Foundries, and not as works manager, as erroniously stated in this department a month ago. The position of works manager at the East St. Louis plant continues to be filled by P. J. Ward.

V V

R. D. Nye has been appointed electrical engineer with the United Alloy Steel Corporation. Canton, O. The same company has named H. H. Pleasance manager of sales. E. D. Rogers, who has been vice president and manager of sales, will continue as vice president of the company. Mr. Pleasance has been assistant manager of sales for a number of years.

V V

John D. Hurley, vice president of the Independent Pneumatic Tool Co., Chicago, has been elected president to succeed the late James Buchanan Brady. Ralph S. Cooper, manager of the New York office of the company, has been made vice president to succeed Mr. Hurley and Robert T. Scott, manager of the Pittsburgh branch has been elected a director and member of the executive board.

V V

A. N. Diehl has been appointed assistant to William Whigham, vice president of the Carnegie Steel Co., with offices at Pittsburgh. S. G. Worton, formerly superintendent of the open hearth department at the Duquesne works of the company, has succeeded Mr. Diehl as assistant general superintendent of the Duquesne plant. R. B. Bostwick has succeeded Mr. Worton. F. W. Underwood has been appointed superintendent of river transportation of the Carnegie Company.

V V

Charles C. Lynde, engineering editor of THE BLAST FURNACE AND STEEL PLANT, joined the engineer officers' reserve camp at Ft. Oglethorpe, Ga., on May 21.

V V

At the Annual Meeting of the American Iron and Steel Institute on May 7, the following directors were re-elected for the three-year term ending in 1920: L. E. Block, A. C. Dinkey, James A. Farrell, Elbert H. Gary, Robert Hobson, Charles M. Schwab, Powell Stackhouse. The following condidates for membership were elected to the waiting list:

E. Austin Barnes and Eugene A. King, mechanical engineers, Semet-Solvay Company, Syracuse, N. Y.; Fred R. Drake, vice president, Thomas Iron Company, Easton, Pa.; Charles V. McIntire, chief engineer, Otto Coking Company, 6 Church Street, New York City; John Woodman Higgins, president and treasurer, Worcester Pressed Steel Company. Worcester. Mass.; Frank B. Baird, president, Charles Augustus Collins, second vice president and Harry Yates, vice president and treasurer, Buffalo Union Furnace Company, Buffalo, N. Y.; Harry Halsey Cook, sales manager, Titanium Alloy Manufacturing Company, Niagara Falls, N. Y.; Robert N. Keeney, open hearth superintendent, Atlantic Steel Company, Atlanta, Ga.; James C. Rea, manager of factories. Oliver Iron and Steel Company, Pittsburgh; Walther Mathesius, superintendent blast furnaces, Illinois Steel Company, South Chicago.

V V

At a meeting of the Board of Directors of the Walter A. Zelnicker Supply Company, St. Louis, held April 19, A. R. Topping was elected Secretary of the company.

V V

Farrar & Trefts, Inc., Buffalo, N. Y., announce the appointment of Henry F. Russell, formerly with the Lumen Bearing Company, as sales manager of their grey iron department.

V V

William H. Stevens, of Bellaire, O., has been made furnace superintendent of the Leetonia (O.) plant of the McKeefrey Iron Company.

V V

Arthur W. Lyle, formerly superintendent of blooming, billet and skelp mills at the Aliquippa (Pa.) plant of the Jones & Laughlin Steel Company, has severed that connection to becoming superintendent of blooming mill and rod mills at the Peoria (Ill.) plant of the Keystone Steel & Wire Company.

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CO-OPERATION AND THE MOBILIZATION OF PUBLIC SENTIMENT.*

(Continued from Page 273.)

able to the protection of general business that it is freely predicted she will abandon in the near future her traditional policy of free trade. England has also closely followed Germany in the policy of encouraging capital combinations for trade, even to the extent of assisting such combinations by Government loans, where necessary, thus recognizing that it requires big business to develop national resources or to promote and maintain industry successfully. The dye-stuff trade is a notable case of this character. While coöperation as practiced by the various governments now engaged in war, may be, as claimed by some writers, a "real working of state socialism," I maintain that it is at least enlightened socialism, for through the application of German and English business methods waste is minimized, efficiency stimulated and productivity increased. Germany not only proposes to continue her past coöperative methods, but also proposes to extend her syndicate operations in the future beyond a mere control of sales, her war experience showing that purchases can also be syndicated to advantage, and furthermore, that capital investment when regulated will avoid unnecessary duplication of plants and thus prevent wasteful competition. I am convinced that we also must adopt, as a national system, coöperation as practiced abroad; also enter into reciprocal tariffs: and, furthermore, we must coöperate wherever possible, not only at home, but also with all foreign countries who are reciprocally inclined.

Legislation for Peace Times.

The mobilization of public sentiment by educational processes, however, takes time and we should not delay our efforts to "Wake up America" to the problems of peace and to emphasize the necessity for co-operation. To make this accomplishment practical and possible, constructive legislation of somewhat the following character will be necessary:

First.—Amendments to the Sherman Anti-Trust Act to legalize price coöperation, and subject possibly to government regulation, to become effective after the war, so as to prevent disorderly liquidation of commodity values during the reconstruction period, and to stabilize values thereafter for the protection of the general public.

Second.—Revision upwards of the tariff where necessary to protect home trade against unfair foreign competition; preferential tariff rates, however, to obtain wherever reciprocal trade agreements can be made to our advantage.

Third.—A thorough overhauling of our Marine Laws and the enactment of such amendments as will justify and encourage capital to become interested permanently in the operation of over-seas shipping. If proper protection cannot be given capital to justify it engaging in over-seas shipping and to successfully compete with foreign ships without subsidy, then we should subsidize American shipping.

The method I would suggest for promoting the necessary preliminary campaign of education for the mobilization of public sentiment favorable to this legislative program would be coöperative publicity.

I am thoroughly convinced that no executive or business man, particularly those who are directing the affairs of public corporations, will hereafter fully measure up to their executive or public responsibilities who does not give these questions his most careful thought, and who is not also willing to devote at least part of his time to public service. In a recent discussion of this subject that I had with a prominent Senator, he admitted that one of the great difficulties confronting the nation is that real politics and real business are not well acquainted; that neither fully understands the principles or the motive-power that is driving the other side. * * * * Even Washington, as has been recently remarked, now recognizes the value of coöperation and of a "Gary dinner" when it is desirable to mark prices down.

Immediate Steps.

I would therefore urge upon all of you to "speak, act and serve together" in the work of mobilizing public sentiment for coöperation, for the prevention of waste, for the conservation of our natural resources, for the encouragement of thrift, and for the general prromotion of the public welfare. Let me also urge upon you to enlist for this service now; begin your campaign at home, educate your local Chamber of Commerce to our business needs, urge the coöperation of your local press, and also endeavor to educate your employes, as some employers now do, by the distribution of leaflets on pertinent subjects through the pay envelope, or by the distribution of other literature, to the viewpoint that your interest is their interest. Furthermore, we should impress upon our representatives both in House and Senate that their coöperation in this general welfare work will hereafter be considered by their constituency as part of their official obligation. As a preliminary step towards educating the employe of foreign birth in the fundamentals of citizenship, we should also give more active support to the Americanization movement by coöperating with the Y. M. C. A. and our local Boards of Education. As evidence of the practical character of this coöperative work, the Youngstown, Ohio, Americanization Committee reports that 144 foreigners, representing 16 different nationalities, were graduated during May into full citizenship after passing all the educational tests required.

As both "big and little business" are loyally supporting the government in times of war, "big and little business" should demand loyal support by the government in times of peace.

BEEHIVE OVEN BUIILDING AT LOW EBB.

The production of beehive coke in 1916 was the greatest ever recorded in the United States, and the average value per ton was higher than in any previous year. The official figures for 1916, just published by the United States Geological Survey, Department of the Interior, show that 35,464,224 tons of beehive coke, valued at $95,468,127, were produced last year, an amount differing by less than 1 per cent from the preliminary estimates of C. E. Lesher, of the Geological Survey, published on January 1, 1917. The output in 1916 represented an increase over 1915 of 7,655,969 tons, or 29 per cent, in quantity, and $38,522,584, or nearly 68 per cent, in value. The average value per ton of the coal used in making beehive coke in 1916 was $1.26, an increase of 21 cents, or 20 per cent, and the average value of the coke was $2.69, an increase of 62 cents, or 30 per cent.

The number of active beehive ovens in 1916 was 65,605 as against 48,985 in 1915, an increase of 16,620. The number of idle ovens was 25,976, as against 44,125 in 1915. Abandoned ovens numbered 2,265, of which nearly 1,800 were in Pennsylvania and West Virginia. No new establishments and but 104 new beehive ovens at old works were reported to be under construction at the end of 1916, a low record compared with recent years, especially in view of the high prices and steady demand for coke throughout the year. The coke producers evidently recognize the fact that the day of the beehive oven is passing and that after the present abnormal condition is over most coke will be made in by-product ovens. The official figures showing the production of coke in by-product ovens in 1916 have not yet been compiled.

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NEWS OF THE PLANTS

STEEL TONNAGE FOR 1913.

The American Iron & Steel Institut's report on production of steel and rolled steel products for the year 1916 was issued on May 24. It shows the total steel output for the year to have been 42,773,680 tons, or more than 10,000,000 tons in excess of the 1915 total. Of this, 41,401,917 tons were ingots and 1,371,763 tons were castings. In ingots and castings combined, the totals were, by grades, as follows, in three years:

PROCESS.	YEARS 1913	1914	1915	1916
Basic, O. H.	20,344,626	16,271,129	22,308,725	29,616,658
Acid, O. H.	1,255,305	903,555	1,370,377	1,798,769
Bessemer	9,545,706	6,220,846	8,287,213	11,059,039
Crucible	121,226	89,869	113,782	129,092
Electric	30,180	24,009	69,412	168,918
Miscellaneous	3,831	3,622	1,527	604
Total	31,300,874	23,513,030	32,151,036	42,773,680

Included in the 29,616,658 tons of basic open-hearth steel ingots and castings produced in 1916 are 3,436,457 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 1,781,491 tons in 1915, an increase of 1,654,966 tons, or 92.9 per cent. In 1914, the production was 835,690 tons and in 1913, 2,210.718 tons. The alloy steel output was:

	Ingots	Castings	Total
Year 1913	625,430	88,927	714,357
Year 1914	577,107	69,846	646,953
Year 1915	923,251	97,896	1,021,147
Year 1916	1,306,157	56,458	1,362,615

Rolled iron and steel in all forms (including blooms, billets and axle blanks rolled for forging purposes and semi-finished products rolled for export) showed an increase of 32.7 per cent over 1915. The totals are as follows:

PRODUCTS.	YEARS 1913	1914	1915	1916
Iron and steel rails	3,502,780	1,945,095	2,204,203	2,854,518
Plates and sheets	5,751,037	4,719,246	6,077,694	7,453,980
Nail plate	37,503	38,573	31,929	30,088
Wire rods	2,464,807	2,431,714	3,095,907	3,518,746
Structural	3,004,972	2,031,124	2,437,003	3,029,964
All other rolled	10,030,144	7,204,444	10,546,188	15,403,093
Total	24,791,243	18,370,196	24,392,924	32,380,389

In all divisions shown above, the 1916 totals are new high marks, with the exception of rails. The rail tonnage of 1916 was exceeded in ten previous annual totals—namely, those for 1901, 1902, 1903, 1905, 1906, 1907, 1909, 1910, 1912, and 1913. The following table itemizes finished product outputs for 1916, specifying iron and steel:

Products.	Iron	Steel	Total
Rails	.....	2,854,518	2,854,518
Plates and sheets	13,303	7,440,677	7,453,980
Nail and spike plate	2,979	27,109	30,088
Wire rods	867	3,517,879	3,518,746
Structural shapes	1,823	3,028,141	3,029,964
Merchant bars	993,948	5,625,598	6,619,546
Bars for reinforcing concrete work	2,683	458,717	461,400
Skelp, flue, and pipe iron or steel	355,445	2,572,229	2,927,674
Long angle splice bars, tie-plate bars, etc.	77,656	614,164	691,820
Hoops	630	367,534	368,164
Bands and cotton-ties	.....	173,311	173,311
Rolled sheet piling, not including fabricated	.....	19,196	19,196
Railroad ties	.....	34,311	34,311
Rolled forging blooms, forging billets, etc.	549	2,015,411	2,015,960
Exports of blooms, billets, sheet bars, etc.	.....	512,483	512,483
All other finished rolled products	372,688	1,296,540	1,669,228
Total, gross tons	1,822,571	30,557,818	32,380,389

To the 19,196 tons of rolled steel piling reported above should be added 4,848 tons of fabricated sheet piling produced during the year. The report on production of finished rolled forms by States shows that, of the total production in 1916, 47.65 per cent was rolled in Pennsylvania, as compared with 49.17 per cent in 1915; and in 1916, 18.05 per cent was rolled in Ohio, as compared with 19.41 per cent in the previous year.

Statistics on production of plates are itemized as follows:

Kinds.	YEARS 1915	1916
Universal plates	954,852	1,224,234
Sheared plates—		
Rolled on single stands	1,626,559	1,982,863
Roughed and finished on separate stands	296,640	470,287
Black sheets made on sheet or job mills	1,836,786	2,249,597
Black plates, including black plates for tinning and black plate specialties rolled on tin mills	1,362,857	1,526,999
Total	6,077,694	7,453,980

Classified by size and mode of manufacture, the production of plates and sheets shows the following totals:

Kinds of products.	Iron	Steel	Total
Universal plates, inc. flats or bars over 6 in. wide:			
¼ of an inch and over in thickness	4,013	1,166,952	1,170,965
Under ¼ of an inch thick	2	53,267	53,269
Total universal plates	4,015	1,220,219	1,224,234
Sheared plates:			
¼ of an inch and over in thickness	1,142	1,864,500	1,865,642
Under ¼ of an inch thick	321	587,187	587,508
Total sheared plates	1,463	2,451,687	2,453,150
Black sheets, made on either sheet or job mills:			
No. 12 gauge and thicker	29	271,780	271,809
No. 13 gauge and thinner	5,918	1,971,870	1,977,788
Total black sheets	5,947	2,243,650	2,249,597
Black plates rolled on tin mills:			
Black plates for tinning	1,878	1,281,924	1,283,802
Other black plate specialties	.....	243,197	243,197
Total black plates rolled on tin mills	1,878	1,525,121	1,526,999
Grand total of plates and sheets	13,303	7,440,677	7,453,980

By widths, the tonnage of universal plates is divided as follows:

Width of universal plates	Iron	Steel	Total
Under 30 inches wide	4,015	952,571	956,586
30 inches wide, but under 48 inches wide	.....	247,545	247,545
48 inches wide and over	.....	20,103	20,103
Total	4,015	1,220,219	1,224,234

CONTRACTS FOR NEW WORK.

A new steel works is being built at St. Francis, Wis., a few miles south of Milwaukee, by the Valley Steel Company, recently organized. The first unit will consist of two 80-ton open hearth furnaces, three 10-ton and one 1½-ton electric furnace. foundations for which have been laid. W. E. Moore & Company, consulting engineers, Pittsburgh, who have charge of the construction of the plant, have designed a 24-inch billet mill and a 104-inch plate mill. A contract for a 10-inch merchant bar mill has been awarded to the United Engineering & Foundry Company, Pittsburgh.

MANUFACTURERS' PUBLICATIONS.

Tht Link-Belt Company has issued, as Booklet 253, under the title, "The Ideal Drive for Cement Mills," a description of a large Link Belt silent chain drive installation at the plant of the Nazareth Cement Company at Nazareth, Pa. Other Link-Belt booklets received are:

Traveling Water Screens for Condenser Intake, No. 305,
Blue Diamond Coal Company Tipple, No. 308,
Increasing Profit by Saving Expense in the Handling and Storing of Coal and Ashes, No. 304,
Some Modern Coal Tipples, No. 303.
Link-Belt Silent Chain Data Book No. 125, 1917 edition.

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This is the only work of its kind ever published and seems likely to enjoy a wide popularity.

Wagon and truck loader catalog, No. 270.

The Smith Gas Engineering Company, Lexington, O., has issued an elaborately illustrated catalog, showing Smith Type "MB" gas producer plants delivering cold, clean gas from bituminous coal. Analyses and charts containing much new data, and illustrations of existing installations are features of the publication.

Cutler-Hammer, of Milwaukee, have issued Booklet "E," describing C-H Control Equipment for Electric Elevators. This booklet covers the various classes of control, such as. Hand Rope Control, Car Switch Control, Push Button Control, for all classes of freight and passenger service.

Tate-Jones & Company, Inc., Pittsburgh, have issued a new edition of their booklet "Heat Treating of Steel," bringing much operating data up to date. New formulae and changes in existing methods are given in compact and convenient form.

The American Steel Export Company, Woolworth building, New York, has issued a booklet entitled, "Export Engineering and Contracting," which deals with its organizaation and service and contains valuable rules for export shipments.

SAFETY NOTES.

The new emergency hospital of the LaBelle Iron Works has been opened at Wheeling, W. Va. Dr. Curtis Laughlin is in charge of this unit.

The record for this much of 1917 at the South Works of the Illinois Steel Company, South Chicago, Ill., shows a reduction of 48 per cent in accidents as compared with the record for 1916.

REMOVAL OF OFFICES.

The Pittsburgh Steel Company, Pittsburgh, has removed its offices from the Frick building to the Union Arcade building.

The Draeger Oxygen Apparatus Company, formerly located at 422 First avenue, Pittsburgh, has removed its plant and offices to the Boyd building, Hay street and Sawyer way. Wilkinsburg, Pa.

TRADE ORGANIZATIONS.

The American Board of Scrap Iron Dealers organized at an informal meeting held in the Ft. Pitt hotel, Pittsburg, on May 15, with the following officers:—President, W. J. Shroder, Cincinnati; secretary and treasurer, C. A. Barnes, Philadelphia; executive committee, Eli Joseph, New York; Joseph Michaels, Charles Dreifus, Pittsburgh; Vernon Phillips, Boston; A. J. Bialsky and Harry Grant.

Pittsburgh Section, American Institute of Electrical Engineers, at its June meeting, at the Monongahela house, Pittsburgh, on June 16, will hear a paper on "By-Product Coke Ovens in the Steel Industry," by James Farrington. There have been quite a number of By-Product Coke Oven Installations in the various steel plants in the vicinity of Pittsburgh, which will be touched on in the paper.

The United States Geological Survey, Department of the Interior, has just published a report on the zinc resources of each zinc-producing State in the United States, accompanied by a map showing the location of zinc-producing districts, zinc smelters, electrolytic zinc plants, and zinc oxide plants, and by tables showing the priduction fir several years. A copy of this report, which was prepared by C. E. Siebenthal, may be obtained by addressing the Director, U. S. Geological Survey, Washington, D. C.

RECENT PATENTS

The following patents are reported expressly for The Blast Furnace and Steel Plant, by E. G. Siggers, patent attorney, Suite No. 31, National Union building, Washington, D. C., from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps:

William A. Darrah and Samuel Trood, of Wilkinsburg, Pa., have invented improvements in vapor treatment of metals, No. 1,224,339, dated May 1, 1917. The invention relates to methods of treating metals by the introduction of other substances into them. It is frequently desirable to change the qualities of a metal by the addition of other metals or other substances, and it may be expedient for reasons of cost, or otherwise to effect this addition after the metal is brought into the final form: in other words, under conditions such that a surface alloy or compound is preferable to a homogeneous metal. The invention, therefore comprises a method of forming a surface compound or alloy which possesses the desired properties. Thus we may treat iron so that the outer layer will be rust proof; we may treat copper or iron, etc., so that its outer layer will be extremely hard or extremely tough, or resist certain agents, etc.

Samuel Trood, of New Castle, Pa., assignor to Industrial Development Company, a corporation of Pennsylvania, has invented improvements in a machine for continuous treatment of metals, No. 1,224,340, dated May 1, 1917. The invention relates to the coating of metals with a protecting layer and more directly to the process of forming a metallic or other coating, by the vapor process, and provides a device for continuously subjecting a new supply of metal to the treating conditions and removing the portion of metal already treated.

August S. Lind, of McKeesport, Pa., has invented improvements in an apparatus for polishing rolling mill rolls, No. 1,224,389, dated May 1, 1917. The invention relates to an improved apparatus for polishing rolling mill rolls and it comprises a series of removable polishing blocks, held in contact with said rolls by means of spring-actuated holders, arranged in oblique positions, the one overlapping the other, a means for placing a pressure upon said blocks, and a means of maintaining said pressure; together with the certain details of construction and combination of parts, as will be fully described hereinafter. In the present practice and method of rolling "tin plate," and also all sheet metals, it is necessary to "close the mill" at certain intervals, in order that the rolls may be polished, for reasons well known in the art. This necessitates a considerable delay, resulting in the loss of time, expense, trouble and increased cost of the product. The object of this invention is to place a permanent polishing apparatus in connection with each set of rolls, that will continuously polish said rolls while the same are in operation, without interfering with the workmen or product of the mill.

Frank D. Carney and Lewis B. Lindemuth, of Bethlehem, Pa., have invented improvements in manufacture of steel, No. 1,223,030, dated April 17, 1917. This invention relates to the manufacture of steel by the duplex process, namely, where the pig iron is first treated in a Bessemer converter, and then treated under basic conditions in a basic lined open hearth, or equivalent, furnace for further purification. The steel is then run into ingot molds, and the ingots suitably treated and manufactured into commercial rolled shapes. The method comprises charging Bessemerized metal into a basic open hearth furnace with sufficient manganese bearing material to produce a slag under basic conditions whose manganese content is sufficiently great to permit a reduction of a portion of said manganese content and cause its entrance into and its retention in the metal of the bath beneath it.

James C. Davis, of Hinsdale, Ill., has invented improvements in apparatus for handling molten steel, No. 1,223,479, dated April 24, 1917, and he has assigned the same to American Steel Foundries, of New York, N. Y., a corporation of New Jersey. This invention relates to the art of producing steel and has particular reference to a novel ladle for use in connection therewith. The ladle is provided with a plurality of openings in its side wall near its upper end, said openings being spaced apart vertically and means for plugging said openings.

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Strength and Inner Structure of Mild Steel

(Continued from Page 282.)

facturing processes may account for this, because it must not be forgotten that iron is produced by processes which do not involve the melting of the iron at any stage. On the other hand, steel is made from a re-melt of the pig-iron produced in the blast furnace, and carbon is added to it in the bath in the form of ferro-manganese. Sir Robert Hadfield gave me some very pure Swedish iron containing only 0.04 per cent of carbon, and the average of six tests on this material gave an ultimate strength of 18.8 tons per square inch. From the diagram immediately to be described, it is deduced from this and other data that the ultimate strength of pure iron is about 16 tons per square inch.

The ultimate strengths of a series of steels are plotted against their respective pearlite contents in Fig. 9. The scale of carbon content is added below the pearlite scale. Point 1 is the ultimate strength of good Swedish iron containing 0.04 per cent of carbon. Point 2 corresponds to a steel containing 0.9 per cent of carbon, and its structure is shown in Fig. 3. The line joining points 1 and 2 cuts the vertical axis through the origin at 16, indicating that the ultimate strength of carbon free iron which has been worked is probably about 16 tons per square inch. The ultimate strength of the 0.57 carbon steel shown in Fig. 6 is plotted in point 3, and point 4 corresponds to the structure shown in Fig. 7. Other points are plotted on the diagram showing the results of tests made on annealed steels of known carbon contents. Variations of ultimate strength from any linear law are to be expected owing to the effects of the various impurities Mn, Si, S and P, but the nearness of the points to the line suggests that the line fairly represents the strength of steel in terms of the pearlite content at any rate to a first approximation.

Introducing the values therefore—

$$f_i = 16 \text{ tons per square inch}$$
$$f_p = 62 \text{ tons per square inch.}$$

equation (2) above becomes—

$$f_s = 1.11\ c\ (62 - 16) + 16 = 51\ c + 16 \qquad (3)$$

This relation therefore represents the ultimate strength of good commercial steel of normal quality after annealing to allow the pearlite to form. Overstrained steels or steels containing excess of any of the ordinary impurities would show departures from the general law.

Characteristic Curves.

Fig. 10, is a facsimile of the diagram corresponding to point 5, Fig., 9, and shows well the characteristic curve for steel, namely, an elastic part joined to a plastic part by an irregular link beginning with a definite drop from the breaking-down load.

A selected number of these load-extension diagrams have been reduced to a common scale of ultimate stress and elongation for the sake of comparison and are plotted over one another in Fig. 11. The progressive decrease of ductility with increase of strength brought about by increasing proportions of pearlite in the structure is well exhibited by these curves.

Figs. 12, 13, 14, show the different inner structures of a piece of the same steel brought about by different rates of cooling. The steel sample, the structure of which is seen in Fig. 12, was heated to 900 deg. C. and quenched rapidly in water; the resulting structure is seen in Fig. 13. It was then heated again to 900 deg. C. and cooled slowly; the original pearlite structure was recovered, as will be seen in Fig. 14. The original pearlite structure seen in Fig. 12 is finer in texture and the pearlite blocks are smaller than in the recovered pearlite structure seen in Fig. 14. The structure Fig. 12 was formed in the bar before the small cube, which was afterwards polished and etched, was cut off. The annealed structure Fig. 14 was produced by heating and slowly cooling this small cube. The circumstances of the formation of the two structures were therefore different both as regards the internal pressures produced by cooling and the configuration and slope of the lines of heat flow.

Structural Changes in Pig Iron.

As mentioned above, the pearlite structure of pig iron shown in Fig. 8, is not the only structure in the metal. As the field of view is changed other structures of remarkable beauty appear. A general view of a polished and etched surface of a piece of Cleveland mottled pig-iron, under the moderate magnification of 62 diameters, is shown in Fig. 4, and seen in the microscope reminds one irresistibly of mountain scenery. The crystal network is a mixture of iron-carbon and phosphorus in the most fusible proportion. Fig. 5, seen in connection with Fig. 4, shows an area of this general figure on an enlarged scale. Pearlite structures are here seen.

These structures are not all formed at one temperature as the metal cools neither are they dissolved into liquid iron at one temperature. A remarkable series of changes takes place in the solid before the metal is actually melted. Imagine that a piece of the metal can be placed in a crucible in circumstances which enable its inner structure to be projected as a picture on a screen so that we can look at the picture during the process of heating and liquefaction. The first picture on the screen would be like Fig. 4, and this would remain until the temperature reached about 725 deg. C., when the pearlite would fade away. The sheets of cementite would, though solid, dissolve into the sheets of solid iron and produce a homogeneous mixture of cementite and iron; the mixture called austenite. The geography of the picture would remain the same, but from this point onwards the cemetite crystals (seen clearly in Fig. 4) round about the gray masses of austenite would in part be absorbed into them, because iron is able to dissolve increasing quantities of cementite as the temperature rises. At about 953 deg. C. the iron-phosphorus-carbon mixture (seen plainly in Fig. 5,) would melt and the temperature rising there would be pockets of liquid material distributed through the still solid mass of austenite and cementite crystals. At about 1,100 deg. C. the cement crystals would melt and the austenite would begin to melt, and would go on melting with rising temperature until the mass was wholly liquid.

Evolution During Cooling.

If now the temperature were allowed to fall again the operations would take place in the reverse order. First crystals of the solution of iron and cementite would grow in the fir-tree form, and not until the temperature had fallen to about 1,100 deg. C. would the cementite begin to form crystals on its own account. The cooling mass would then appear as a conglomerate of fir-tree blocks or crystallites, the crystal elements of which are formed of a solution of cementite in iron austenite, and separate crystals of pure cementite, and these would by now be solid; but distributed through the solid mass would be liquid pockets of the iron-phosphorus-carbon mixture about to form the crystal net-like structure when the temperature has fallen to 953 deg. C. The picture would now show a mass completely solid; but probably much change in the geography would be noticed as the mass colled, because the cool structure exhibits the crushed and distorted remains of the fir-tree crystallites, and they appear to have been subject to great pressure during the cooling process. A cursory examination of the enlarged photograph in Fig. 5 will show how the regular growth which is indicated by the remains of an uncrushed crystallite enmeshed in crystals of cementite is distorted in the dark areas into blocks of irregular form. Finally at 725 deg. C. we may assume that the geography has settled down to its final shape, and then, given time and patience, all the dark areas would be seen to change into the laminated structure of pearlite.

Each one of these changes is accompanied by heat evolution, and it is this heat evolution which enables the changes to be traced. The process of identifying changes of structure with heat evolution is a laborious one, as will be understood from the Reports of the Alloys Research Committee of the Institution of Mechanical Engineers, reports which are no doubt familiar in a general way to most of us. Professor Carpenter has made extensive researches into the matter, particularly in relation to iron and steel, and has obtained data for the construction of the temperature concentration diagram for carbon in iron. This diagram is exceedingly useful to us as users of steel, and furnishes a key to many apparently disconnected workship processes which have been derived from experience, and which have been tested by experience but are none the less founded on and connected by underlying bonds of pure science. Professor Carpenter has kindly promised to give us a paper next year on the diagram which his own researches have done so much to establish.

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Steel Plant Incorporations and Construction

Blandon, Pa. — The Blandon Rolling Mills, Inc., recently incorporated with a capital of $150,000, has acquired the property of the former Blandon mill, and will commence immediate operations. F. C. Smink is president, and Samuel R. Seyfert, treasurer and manager.

Philadelphia, Pa. — The American Manganese Manufacturing Company, Bullitt building, is remodeling and making extensive improvements at the former blast furnace of the Lochiel Steel Company, South Harrisburg, recently acquired from the Bethlehem Steel Company. Plans are being made to place the plant in operation about June 15, with capacity of 125 tons of pig iron daily.

Allentown, Pa. — The National Slag Company has received a contract from the Bethlehem Steel Company for furnishing material for its blast furnaces at Lebanon and Cornwall. To provide increased capacity the company will soon commence the installation of a 600-ton crushing plant.

Hamburg, Pa. — The plant of the Multiple Parts Company has been acquired by new interests, headed by Daniel J. Driscoll, and will be remodeled for a steel mill. The building will be doubled in size for increased capacity, with provision for the installation of an electric furnace, work on the latter being under way.

Pottstown, Pa. — Announcement has been made by the Nagle Steel Company, that the plant of the Potts Brothers Iron Company, recently acquired, will be placed in operation as an extension to the company's works on June 15, or closely following. The plant has been remodeled and extended, as well as equipped for plate mill and other operations.

Dover, N. J. — The Fulton Iron Works Company has been incorporated with capital of $6,000,000, to manufacture iron and steel products. The local incorporators are Herbert E. Latter, C. L. Rimlinger and Clement Eger, Wilmington, Del.

Newport News, Va. — The Newport News Shipbuilding & Drydock Company is considering extensions in its plant, to cost over $500,000 within the next year. An addition will be erected to the foundry for the production of steel castings, an extension made to the machine shop, between the present shop and the boiler and forge plants. New ship ways are also contemplated.

Charleston, W. Va. — The Vulcan Iron Works, West Charleston, has been acquired by new interests, headed by G. T. Thayer. It is reported that the new owners plan for improvements and extensions in the present plant, as well as removal to a new site.

Steelton, Pa. — Blast Furnace No. 3, of the Pennsylvania Steel Company, now operated by the Bethlehem Steel Company, will be relined and improved. The furnace was recently shut down for this purpose.

Jersey City, N. J. — The Dodge-Welden Iron Company has been incorporated with a capital of $540,000, to operate an iron and steel works. Harry Osborne, Andrew F. Mayer and John F. Simpson are the incorporators.

New York, N. Y.—The Eagle Wrought Iron Company, 580 Jackson avenue, has filed plans for a two-story extension to cost about $10,000.

Reading, Pa. — The Reading Steel Casting Company, manufacturer of steel and iron castings, etc., is having plans prepared for a one-story extension, about 50x60 ft. Wm. H. Dechart & Son, Baer building, are the architects.

Philadelphia, Pa. — The Midvale-Cambria Company has recently been incorporated with a capital of $100,000, by Alva C. Dinkey, president of the Midvale Steel Company and associates, to manufacture iron and steel products. The incorporators are Mr. Dinkey; John C. Neale, Philadelphia, and E. E. Slick, Johnstown.

Hazleton, Pa. — The Jeanesville Iron Works will remodel and improve its machine and other departmests to provide for a large munition order.

Wilkes-Barre, Pa. — The Pressed Steel Company is having plans prepared for a one-story, concrete addition, 57x80 ft., to cost about $10,000.

Waterbury, Conn. — Waterbury Rolling Mill Company will build $50,000 plant extension.

Chicago, Ill. — Calumet Steel Company, 208 South La Sallet street, expects to build a 75x150-foot tube finishing plant.

Harrisburg, Pa. — In connection with other improvements and extensions, the Central Iron & Steel Company is planning for the erection of an extension, 30x300 ft., to its open-hearth plant. A new furnace now in course of construction will be placed in operation about June 15. It is expected that the receivership existent since February, 1912, will soon be discharged, the local court receiving application from President Robert H. Irons, showing that outstanding debts have all been defrayed and the first mortgage reduced from $1,320,000 to $637,000.

IRON AND STEEL QUOTATIONS

COMPARED WITH PRICES OF A MONTH AGO

PIG IRON.

Pittsburgh*—	April 26	May 25
Bessemer	42.95@ 44.95	45.95
Basic	40.95@ 42.95	42.95
No. 2 foundry	40.95@ 42.95	42.95@ 43.95
Malleable	40.95	42.95@ 43.95
Gray forge	38.95	41.95
Ferro-silicon, 50%	300.00	200.00@250.00
Ferro-silicon, 10%	60.00@ 62.00	65.00
Ferro-mang., 80%	425.00	350.00@400.00
Spiegeleisen, 20%	75.00@ 80.00	75.00@ 80.00

* Pig iron prices quoted here are at Pittsburgh, with freight rate from Valleys to Pittsburgh, 95 cents added.

Virginia Furnaces—		
Basic	35.25@ 37.25	38.00
No. 2X	38.00@ 39.50	40.00@ 42.00
No. 2 plain	37.50@ 39.50	39.00@ 40.00
Gray forge	37.00@ 39.00	39.00
Philadelphia (del.)—		
No. 2X foundry	42.50@ 43.00	44.00@ 45.00
No. 2 plain	42.00@ 42.50	42.00
Basic	38.00@ 40.00	40.00@ 42.00
Gray forge	39.75@ 41.75	40.00@ 42.00
Chicago (at fur.)—		
No. 2 foundry	41.00	45.00
Malleable	41.00	44.00@ 46.00
Basic	41.00	44.00
Cincinnati (del.)—		
Northern No. 2 fdy	39.26@ 40.26	44.26@ 45.26
Basic	39.26@ 40.26	42.26@ 44.26
Nor. malleable	39.26@ 40.26	42.26@ 44.26
Birmingham—		
No. 2 foundry	35.00@ 36.00	39.50@ 40.50
No. 3 foundry	34.50@ 35.50	38.50@ 40.00
Gray forge	34.00@ 35.00	38.00@ 39.00

STEEL.

Tons of 2,240 lbs., at Pittsburgh.		
Bessemer billets	75.00@ 80.00	90.00
Open hearth billets	75.00@ 80.00	90.00
Forging billets	100.00@110.00	110.00@115.00
Sheet and tin bars	80.00	90.00
Wire rods	85.00@ 90.00	85.00@ 90.00

FINISHED PRODUCT.

Tons of 2,000 lbs.,		
Skelp, grooved	70.00	70.00
Skelp, sheared	110.00	110.00
Sheets, No. 28	120.00@130.00	140.00@150.00
Galvanized sheets	140.00@150.00	160.00@170.00
Shapes	72.00@ 75.00	80.00
Plates	110.00@120.00	130.00
Hoops	80.00@ 90.00	85.00@ 90.00
Bands	70.00@ 75.00	75.00@ 85.00
Steel bars	70.00@ 75.00	80.00@ 85.00
Iron bars	75.00@ 78.00	80.00
Per lb. on large orders:		
Tin plate	7.50@ 7.75	7.50@ 7.75
Plain wire	3.55	3.55
Galvanized wire	4.15	4.15
Wire nails	3.50	3.50@ 3.75
Galvanized nails	4.25	5.50

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